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SCHOOL SCIENCE AND MATHEMATICS

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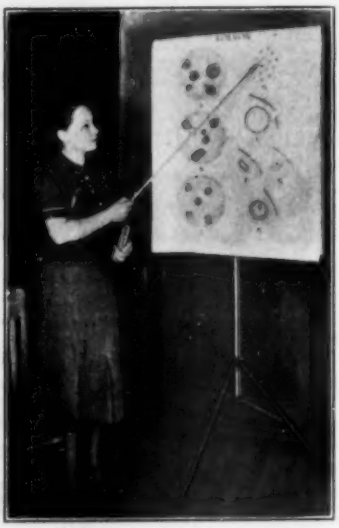

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXXVII DECEMBER, 1937 WHOLE NO. 326

NUMBER AND THE FOUR FUNDAMENTAL OPERATIONS OF ARITHMETIC

BY GLENN JAMES

University of California at Los Angeles

At first thought this subject seems trite, because number, addition, subtraction, multiplication and division are household words all over the country. However, familiarity does not by any means necessitate understanding. A little investigation will convince anyone that such is the case in this instance. In a recent class of sixty, with ability above the average, containing teachers from the first grade to junior college and freshmen to graduate students, the writer found not a single student who clearly understood these concepts. Textbooks that are clear on them are not common; and educators who seek to determine the contents of our arithmetical courses are usually confused on them. This situation has resulted from long ages of teaching arithmetic as a rule of thumb process. There has in the past been no obvious necessity for stressing the meaning of these concepts. It seemed sufficient to commit the rules and practice them. But in the present days when we are, very rightly, becoming more and more realistic in our teaching of arithmetic and are ceasing to impose formal rules on beginners, it is vitally important that teachers have these basic concepts well defined in their minds. Number stories and various objective methods of starting number work lose most of their values if the directing teacher does not see clearly the goals toward which such work should lead. Endeavoring to aid in this matter we will state briefly the meaning to us of these concepts, negate certain very

prevalent misconceptions of them and show how clarity on these points carries students over some of the hardest places in arithmetic and algebra.

A number, that is a positive integer, is the "manyness" of a group of things. More specifically, *Number is that quantitative property of a group which is independent of the natures of the individual constituting the group.* Obviously, the quantitative property is a relative matter like all other properties. A number can only be conceived in relation to some other number. Two is 2 only as compared to 1 or perhaps 3. For this reason, the number concepts do not exist independent of some relation between them. Such relation, like the concepts themselves, although hazily defined in the beginner's mind gradually blossoms into addition as the number concept becomes better defined.

Addition is the recognition of the fact that certain groups taken together form other groups. Counting is a simple form of addition, by which you add the same number each time to your previous sum. If you are counting by ones, you add one; if you are counting by twos, you add two; if you are counting by fives, you add five; etc.

Subtraction is the process of separating a given group into two other groups, one of which has been given. The fundamental principle is the same no matter whether you use the "taking from" or "adding to" method.

Multiplication is addition in the case where all the addends are the same. For example, 2×3 means a group of 3 taken twice or a group of 2 taken 3 times, additively.

Division is the inverse of multiplication. For example, how many groups of 3 are required to make 6 or how many groups of 2 are required to make 6? In the first instance, 6 is divided by 3, and in the second instance 6 is divided by 2. One may choose to think of division as a direct process. The same is true of subtraction. However, we must first choose some one explanation, get clear on that and later broaden our viewpoint by considering other viewpoints. Otherwise, attempts to broaden may lead to confusion.

These four fundamental relations exist between numbers by virtue of the nature of numbers. If you are going to apply them to elements other than numbers by virtue of properties which these elements possess other than or in addition to the number property, you will have to modify these definitions of the fundamen-

tal processes. Indeed, in arithmetic there is no question as to what kinds of positive integers can be added or multiplied. *There is only one kind of integer.* As to whether or not one can combine cows or horses or books and pencils are questions with which number and the fundamental operations are not concerned. Numbers are neither hard, soft, black, inanimate or alive, they do not squeal or give milk. Two pigs plus three cows equals five monkeys as far as the number property in addition is concerned. Unless this be true, number is not independent of the nature of individuals. Biologically there is objection to such a combination of animals, but the combinations that are possible in biology, chemistry, or any other subject must be determined in the light of the objects dealt with in those subjects. Such ultra-mathematical considerations should, we believe, be presupposed by a thorough understanding of what the arithmetic processes really mean in order to make the student recognize that they are not a part of but an addition to the arithmetic processes. It is immensely important that this be kept in mind while working out with pupils the meaning and use of the fundamental operations.

Of course the teacher of arithmetic must start number work with groups of objects which have individual properties sufficiently colorful to engage the interest of the pupil. But it is not difficult to gradually differentiate between such properties and the number property of the group. If, for instance, a student has been using his fingers to add, fingers should be replaced by books, pencils, or what-not in order to instill in his mind the fact that number is indeed independent of the individual characteristics of the fingers, books, pencils, etc.

Unless such clear distinctions as we have been discussing have been made, the student will meet great difficulties as he struggles through his arithmetic, especially in such topics as word problems, denominate numbers, and percentage. These topics offer nothing new or difficult in arithmetic as such. What they stress is the separation of the pure number relations from certain non-arithmetical properties. We will illustrate this with a simple word problem.

John has five dollars; Charles has twelve marbles. Together John and Charles have as many dollars as Charles has marbles. How much money does Charles have?

This is of course nothing but a simple problem in subtraction, namely twelve minus five equals how much? The student meets

difficulty in such problems not in the arithmetical processes, but in separating the number phases of the problem from the extraneous matter, namely John, dollars, Charles and marbles. A clear understanding of the foundation concepts, number and the four fundamental operations, enables him to do this easily.

While it is not pertinent to this discussion to enter into a discussion of the contents of courses in arithmetic, it is fitting to call attention to the fact that recommendations on content of courses would usually eliminate from arithmetic processes which are involved in work that they would substitute. The mathematician stands aghast at recommendations for the substitution of stocks and bonds, life insurance, surveying, et cetera, for certain topics in arithmetic, because he realizes that all the arithmetic now given is not adequate to an understanding of the arithmetical principles involved in these topics. Obviously such recommendations are due to a failure to understand the pure number relations well enough to see that, even though they differ from applied arithmetic, still they constitute its frame work.

SMOKE

Anywhere from 10 to 30 dollars is the annual loss sustained by each person in the U. S. because of the presence of smoke in the atmosphere, according to estimates made by the Public Health Service. The smoke bill can be attributed to clothes cleaning, disfigurement of buildings, damaged merchandise, injuries to grass and plants, and the loss of light and ultraviolet light. In some cases it was found that ultraviolet light was 50 per cent greater in rural areas than in cities.

Air pollution being present everywhere, attempt is made merely to reduce it to a concentration that is hygienically safe. In cities the volume of material deposited from the air is as much as 100 tons per square mile per year in exceptionally clean areas, and several thousand tons in sections heavily polluted.

CARBON DIOXIDE DAYLIGHT LAMPS PERFECTED

Carbon dioxide filled incandescent lamps, providing an artificial daylight claimed to be a wide improvement over any previous type of artificial daylight lamp, have been commercially perfected, the Optical Society of America was told at Lake Placid, October 14.

The lamp is suitable for matching colors, the test which has proved the undoing of most previous artificial lights, Dr. Thomas J. Killian of the Barkon Tube Lighting Corporation declared.

Previous attempts to use carbon dioxide in lamps, a long-sought goal because of its white spectrum, have failed because of the tendency of the gas to break down under the electric charge sent through it, with consequent changes in its pressure and behavior. A simple electronic control for the pressure is the new feature of the light, Mr. Killian asserted.

A SIMPLE FORM OF THE WILSON CLOUD CHAMBER FOR PROJECTING ALPHA TRACKS

By N. Henry Black

Jefferson Physical Laboratory, Harvard University

It was a little more than twenty-five years ago that C. T. R. Wilson of Cambridge, England, described[1] his method of making visible the paths of ionizing particles through gas. Since then many physicists have modified the form of the apparatus. But no one has stated more clearly than he did the necessary conditions for successful operation and construction. "It is

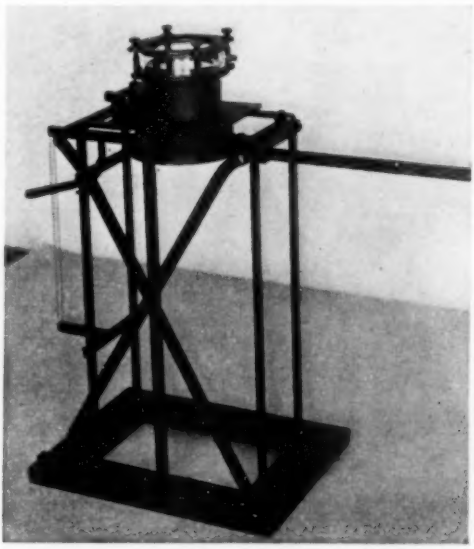


Fig. 1. Wilson cloud chamber mounted for projection.

necessary that little or no stirring up of the gas should result from the expansion. It is desirable that no interval long enough to allow of appreciable diffusion of the ions should elapse between their liberation and the production of the super-saturation necessary for the condensation of water upon them; and that the cloud chamber should be free from all ions other than those in the freshly formed trails."

Physics teachers have long been looking for a simple form of

[1] C. T. R. Wilson, *Proc. Roy. Soc. 85*, 285 (1911).

the Wilson "expansion chamber" which was adapted to demonstration purposes. To be sure, H. T. Pye has described[2] a modification of the Wilson apparatus for projection purposes. His apparatus, however, seems a bit complicated and expensive to build. Many of us have, doubtless, used the Cenco-Knipp apparatus, which works admirably for small groups, but it is not adapted to show the tracks to a large class.

Last summer Dr. Franz N. D. Kurie of the Radiation Laboratory of the University of California at Berkeley showed me his

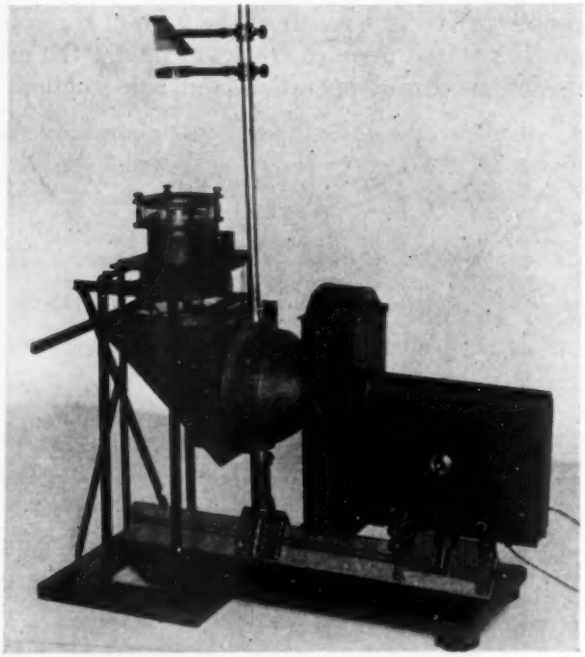


FIG. 2. Chamber and projecting arc lantern.

form of the Wilson "cloud chamber," which seemed so well adapted for projecting the alpha tracks, that I have had one built in our own shops along the same lines. The apparatus is now completed as shown in figure 1. We built it to use with one of our vertical projectors, which happens to be the pohl type made by Spindler & Hoyer of Göttingen, Germany. The Wilson cloud chamber modified for vertical projection is shown in figure 2 with the projecting arc lantern, condensing lenses, projecting lens, and reflecting prism.

[2] H. T. Pye *Journ. Sci. Instr.*, Vol. II, pp. 199 (1925).

The details of the construction are shown more clearly in the sectional drawing (figure 3). The chamber itself consists of a cylindrical box with top, bottom, and sides made of glass. The short glass cylinder (*Cyl*) with its plate glass cover (*G*) is clamped on the end of a hollow brass cylinder (*C*). Inside of this tube is a hollow brass piston (*C'*) which is also provided with a plate glass cover (*G'*). This glass plate (*G'*) is fastened into the top of the piston (*C'*) as follows: First, a fine thread is cut on the inside of the cylinder near the top edge. Then a brass shoulder-

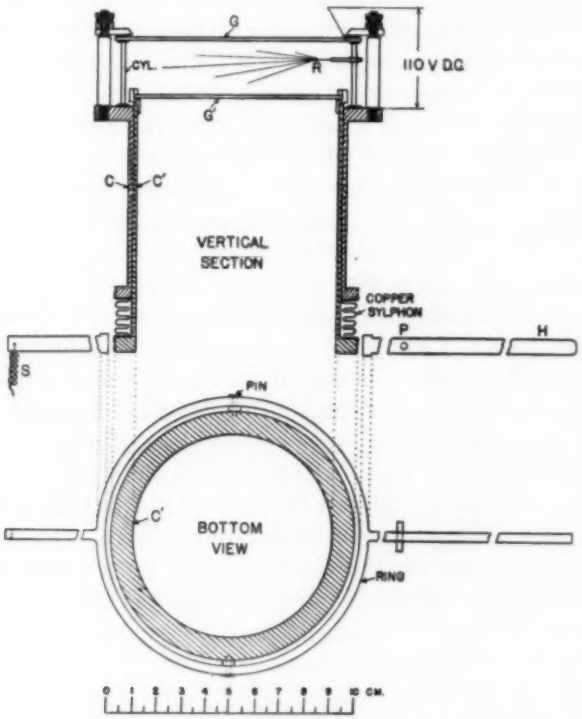


FIG. 3. Vertical section and bottom view of chamber.

ring is turned and threaded to fit this cylinder as shown in the diagram. The glass plate is held in position by another brass ring which is threaded to fit inside the shoulder-ring. A rubber gasket is placed under the glass plate. This inside cylinder can be pushed up a few millimeters by means of a ring and lever handle (*H*) which is attached to the bottom of the piston. In order that the cloud chamber may be air-tight and yet allow the bottom (*G'*) to move up and down a little, we have joined the bottom of the fixed outer cylinder (*C*) with the movable

inner cylinder (C') by means of a short piece of copper "sylphon" tubing[3] which is soldered firmly to each tube. In order to compress the air in the chamber, we have merely to push down on the lever at H, which turns about the pivot at P and so raises the ring around the cylinder. This action pushes up the piston by means of the two pins (shown in the bottom view). Since the piston moves up only two or three millimeters, it is only necessary to have the pins fit a bit loosely to allow for this vertical motion in a straight line while the pins move in the arc of a circle. The expansion has to be fairly rapid and this is arranged for by means of a spiral spring (S) which pulls down the lever and so the piston. The upward and downward motion of the piston is limited by set-screws (not shown in the diagram) which may be adjusted to give the proper ratio of expansion (1:1.2). We have made a trigger which holds the piston in the position of minimum volume and then releases the lever suddenly. But this mechanism jars the apparatus slightly when it is tripped off, so we do not always use it.

In building the apparatus we started with a glass tube which had an inside diameter of about 9 cm. and a wall about 2 mm. thick. We cut off a piece 2.5 cm. long and ground the top and bottom edges smooth. Then we drilled a tiny hole in the side to hold the wire carrying a speck of radioactive material (R) radium F (polonium). The joint between the wire and the glass was made tight with wax (or DeKhotinsky cement). The circular plates for the top (G) and bottom (G') of the chamber were cut out of ordinary clean photographic plates. The top plate was clamped down on the glass cylinder by a brass ring held by four screws as shown in figure 1. Rubber gaskets are used under and above the glass cylinder (Cyl) and also between the top plate (G) and the ring clamp.

In order to clear the chamber of a general fog, it is necessary to maintain an electrostatic field (about 110 volts d-c.) between the brass cylinder (C) and the graphite ring near the edge of the top glass plate. This is done by putting a thin ring of "aquadag" (a suspension of graphite in water) around the lower edge of the circular glass plate, and also extending this layer at one spot around from the lower surface to the top surface of the glass. Then a piece of copper foil is placed on top of the aquadag tab to make the connection with the 110-volt line, and over this a rubber gasket.

[3] T. W. Bonner, *Rev. Sci. Instr.*, 6, 143 (1935).

It is surprising how little moisture is needed to saturate the air within this little chamber. We have merely to dip a camel's hair brush in isopropyl alcohol and then brush over the top edge of the piston head. After the top glass plate is clamped in position and after a few trial expansion strokes, the alpha tracks appear. The best results were obtained by holding the handle down in the position of maximum compression for 10 or 15 seconds and then releasing it. The light from the arc lamp (5 amperes d-c.) is reflected up through the chamber and the water drops either refract or scatter the light according to their size. The projecting lens and the reflecting prism are adjusted to give a sharp image of the wire holding the radioactive material on the screen. The alpha tracks appear as faint dark streaks shooting out in straight lines from the end of the wire (*R*). However, in a well darkened lecture room the tracks are easily seen at a distance of 50 feet or more. After a few seconds these tracks disappear and then we may repeat the process of compression and expansion.

The success of the project of building this apparatus is due not only to the coöperation of my colleagues but also to the skill and patience of my assistant, Mr. Fred Schueler.

SIZE OF NEW SUBATOMIC PARTICLE

The physicist's unchristened baby, the subatomic particle discovered amost exactly a year ago, is between 100 and 160 times as massive as the electron.

This first estimate of the size of the most recent addition to the family of building blocks of the universe was reported in the *Physical Review* by Drs. J. C. Street and E. C. Stevenson of Harvard University.

One thousand photographs of particle tracks produced by the bombardment of matter by cosmic rays were taken by the Harvard scientists in order to secure one photograph of the new particle, it is stated. The estimate of the size is based on the shape of the track the particle left behind it and on its penetrating power.

The particle is believed to carry the same negative electric charge as an electron, for the two Harvard scientists made that assumption in proceeding to analyze results of their lengthy experiments.

Four Geiger counters—devices for counting atomic discharges—were lined up in an ingenious experimental "telescope" layout in order to track the new particle. The first three counters were used to guarantee that particles were coming from only one direction outside the apparatus. The last counter served to cut off the observing chamber when high energy particles, photographs of which were not wanted, passed through the counters. Had this last trap not been used 4000 pictures—instead of 1000—would have been necessary to obtain the one vital atomic portrait for which Drs. Street and Stevenson were looking.

HEAVY WATER

By Saylor C. Cubbage
Woodrow Wilson High School, Washington, D.C.

About five years ago three American chemists, Harold C. Urey, and G. M. Murphy of Columbia University, and F. G. Brickwedde, now of the National Bureau of Standards, discovered an isotope of hydrogen with an atomic weight or mass of two. This isotope of hydrogen has been named deuterium. Since that time another isotope of hydrogen with a mass of three has been discovered. The substance "heavy water" or deuterium oxide is composed of hydrogen atoms with a mass of two combined with ordinary oxygen atoms with a mass of sixteen. The formula for the substance is written D_2O.

The water we use in our daily experience contains one part of heavy water in about five or six thousand parts of ordinary water, i.e., water with light hydrogen in its make-up. It has been found that in the prolonged electrolysis of water there is a continual increase in the density of the water remaining in the vessel. Presumably the water composed of the lighter hydrogen atoms is electrolyzed first and that containing the heavier hydrogen atoms lags behind. Johnston[1] in his work on heavy water subjected fifty liters of ordinary water to electrolysis until 25% had been decomposed. The gases obtained from this electrolysis were exploded and the water formed was again electrolyzed until 25% had been decomposed. After five successive stages of fractional electrolysis a light fraction of 45 cubic centimeters was obtained. From carefully purified samples of the ordinary water and the successive samples of "light water" it was found that the density of the "light" samples had progressively decreased. Johnston concluded that he had obtained water which contained less than one deuterium atom in one million hydrogen atoms. The late Dr. Edward Wight Washburn of the National Bureau of Standards discovered the method of separation of the isotopes of hydrogen by the electrolysis of water. An abundant source of heavy water today is the liquors of electrolytic baths used in the electroplating industries. Baths that have been in use for a considerable length of time have appreciable amounts of heavy water present.

[1] Johnston, Herrick L., *Jour. Amer. Chem. Soc.*, 57, 484 (1935).

Because of the fact that water is slightly over 11% hydrogen by weight one would not expect, contrary to casual thought, to find the so-called heavy water much heavier than ordinary water. The density of heavy water is only about one-tenth greater than ordinary water. Lewis and McDonald[2] report the density of heavy water to be 1.1056 at 25 degrees C. The freezing point is 3.82 and the boiling point 101.42 degrees C. In appearance heavy water resembles ordinary water. Common table salt is not quite as soluble in heavy water as in ordinary water.

Experimental results indicate that heavy water exercises an inhibitory effect upon the germination of some seeds. G. N. Lewis[3] reports certain experiments with tobacco seeds in which the seeds were subjected to the same conditions except that half of them were placed in pure heavy water and the remainder in ordinary distilled water. The seeds placed in the ordinary water began to sprout within two days and at the end of two weeks had developed well-formed seedlings while the others placed in heavy water showed no development. It has been reported that goldfish behave alike when placed in the two kinds of water while other reports claim that tadpoles are quickly killed if placed in heavy water. Heavy water appears to cause no harmful results when taken as drinking water. Barnes and Gaw[4] have found the contractile vacuole of protozoa to be an excellent object for heavy water experiments. The contractile vacuole of Paramecium caudatum empties every 18.9 seconds in 30% deuterium oxide as compared with every 11.3 seconds in ordinary water (all at 18.8 degrees C.). These investigators have studied the effect of deuterium oxide on the green plant cell. In the case of about eleven hundred cells of Spirogyra in 0.47% deuterium oxide in the light of sixty foot candles, 72% were alive and healthy after two days but only 18% of another group survived in the dark. Where ordinary water was used 32% of nearly thirteen hundred cells survived under the same conditions of light intensity and 16% of a group of nearly eight hundred in the dark. One would conclude from the results of these experiments that heavy water in low concentration is favorable to photosynthesis. Reitz and Bonhoeffer[5] find that deuterium is taken directly into the carbo-

[2] Lewis and McDonald, *Jour. Amer. Chem. Soc.*, *55*, 3057 (1933).
[3] Lewis, G. N., *Jour. Amer. Chem. Soc.*, *55*, 3503, (1933).
[4] Barnes and Gaw, *Jour. Amer. Chem. Soc.*, *57*, 591, (1935).
[5] Reitz and Bonhoeffer, *Naturwiss.*, *22*, 744 (1934).

hydrates of green algae. They suggest that the presence of a stronger bond between the heavy hydrogen atom and the adjacent carbon atom favors the production of a more stable intermediate product in photosynthesis (formaldehyde?). They believe further that the carbon to carbon bonds may be strengthened slightly as in heavy acetylene.

One may conclude from theoretical considerations that many variations in the water molecule are possible when one considers the various known isotopes. The first variation to suggest itself would be a molecule of water in which there would be present one atom of hydrogen with a mass of one and the other with a mass of two. This variety of heavy water is known. With the discovery of the hydrogen isotope of mass three many other variations in the water molecule are seen to be possible. Since it is known that oxygen exists in at least three isotopic forms with masses of 16, 17, and 18, respectively, one can readily see that the possible variations in the mass of the water molecule are indeed many. Therefore, in any sample of water there may be present many or all of the possible combinations of the various isotopes of hydrogen and oxygen, any one of which could give a water of different density. In consequence, the density of water as we know it is an average of the densities of the various "kinds of water" present in a sample of pure water, just as the atomic weights of the elements given in our atomic weight tables are averages of the masses of the various isotopes of the particular element.

Many other hydrogen-containing compounds have been studied in which deuterium has taken the place of hydrogen. Many of these have been isolated. These include the hydrocarbons, various acids, ammonia and its compounds, etc. Many interesting variations in chemical and physical properties from those of the well-known hydrogen compounds have been noted.

BUZZARD

Buzzards from Sweden commute to Central Africa. The species is known as the honey buzzard, a fairly common bird in summer in northern Europe. In winter it is distributed over a wide range south of the Sahara. One, captured near here some time ago, had an iron arrow point embedded under its wing. The point was identified as of Fan Negro workmanship, from the Gaboon region. It is known that the migrating birds leave Europe by way of both Spain and Italy, but whether they fly over the empty waste of the Sahara or follow the West African coast line is still an unsolved riddle of science.

THE TEACHING OF GENERAL BOTANY IN LIBERAL ARTS COLLEGES FOR WOMEN

By Sister Mary Therese, B.V.M.
Mundelein College, Chicago, Ill.

During February of the present year members of the botany department of Mundelein College undertook a survey of "*The Teaching of General Botany in Liberal Arts Colleges for Women.*" Unusual interest was manifested in a questionnaire which was sent to 132 colleges located in 32 States. These institutions were chosen because they were listed as fully accredited colleges in the 1936 directory of American Universities and Colleges. Of this number 107 or 81% responded.

The purpose of this survey was to secure scientific data concerning the present status of general botany as it is taught in liberal arts colleges for women. Information bearing on this problem was not readily available and therefore, a questionnaire was resorted to. In order to avoid undue length the questionnaire was limited to salient points. However, much supplementary information was offered by many of the colleges.

With 32 States represented in the returns, it was considered of interest to arrange the colleges territorially and to observe whether or not the teaching of botany varies in the colleges according to location in the New England group, the South Atlantic, the South Central, the North Central, the Western, or the Pacific States. With no further delay a summary of the results will be offered.

With many college administrators it is frequently debatable whether a year course in general botany can, without undue loss to the students, be shortened to that of a semester, or a semester course be profitably extended to that of a year. Many factors such as the teaching load, class registration and laboratory equipment, to mention only a few, must necessarily be considered. Concerning the duration of the course, of those offering general botany, 61% of the colleges have chosen the year course and 36% the semester course. According to territorial rating the distribution is general.

Regarding the choice of method of conducting lecture and laboratory work 13% of the institutions use the combined lecture-laboratory method, and 87% employ separate lecture periods and laboratory periods. In the former group, the combined lecture-laboratory type, the average time is from six to

eight hours per week. In colleges of the separate lecture and laboratory type, the preference rests with two lecture periods per week.

Not infrequently the question is raised: "Should students be required to make their own laboratory drawings or should they be allowed to label prepared drawings?" Ninety per cent of the colleges are in favor of having each student make her own drawings, and 10% favor having her label prepared drawings.

Regularly established quizzes to systematically follow up laboratory work are used in 93% of the colleges. Tests of various types are employed including written and oral, objective and standardized forms here listed in the order of their popularity with instructors. The remaining 7% of the institutions have not established the custom of laboratory testing.

Contrary to common opinions, instructors in botany enrich their courses with the aids to visual education, guest speakers and radio programs. These, along with the usual laboratory variety of equipment of charts and models, are in frequent use in 92% of the colleges. In the order of their frequency of occurrence in the questionnaire returns lantern slides rank highest, the rest in order are: micro-projector, clay modelling, guest lecturers, film slides, silent movies, loan exhibits, talkies and lastly radio programs.

The students' interest is further stimulated and allowed expression through the medium of projects which are carried on outside of regular class periods in 51% of the institutions. The list of topics which follows was compiled from examples offered by colleges and exceeded fifty in number. These, it will be noticed, can be conveniently grouped into suitable seasonal studies.

1—Bog terrarium
2—Bowl garden
3—Charts showing types of inflorescence
4—Classifying leaves and flowers
5—Collections of:
  a—conifers with key
  b—ferns
  c—leaves, seeds and twigs
  d—lichens
  e—mosses
  f—native woods
  g—oak leaves
  h—seeds showing agents of dispersal
  i—seaweeds
  j—thallophytes
  k—weeds

6—Conservation project (Report)
7—Control of harmful fungi (Report)
8—Desert terrarium
9—Dramatizations
10—Ecological survey of native plant distribution according to slope and exposure
11—Germination of prothallia on agar-agar
12—Grafting and budding
13—Growing tulips and other bulbs
14—Herbarium
15—Insectivorous plant terrarium
16—Keeping scrapbook
17—Leaf prints
18—Legume bacteria
19—Light relation of leaves (Experiment)
20—Making and caring for window box
21—Making of lantern slides
22—Medicinal and harmful plants (Report)
23—Mineral nutrition (Experiment)
24—Models of landscape gardening
25—Models of life cycles
26—Observations and records of growth on some plants in greenhouse
27—Observation on sensitive reactions in plants
28—Preserving of fresh material
29—Reforestation (Report)
30—Salt water aquarium
31—Set-up illustrating carbon cycle
32—Small rock garden
33—Soil acidity study (Experiment)
34—Study of biological industrial resources of native state
35—Study of various plant products in industry
36—Studying roots in liquid-series with plant food in water
37—Terrarium containing some of all four phylla
38—Written report on outside readings: lives of botanists, magazine articles, etc.

Without any doubt field trips are considered an essential supplement to theory, and are included in the general botany courses of 86% of the colleges, the average number of trips being 2 or 3 during the semester. Together with this approach to a comprehensive course may be mentioned the use made of college greenhouses where students have the opportunity of cultivating plants and of watching them grow.

Of all the questions proposed for consideration the one that evoked the greatest diversity of opinion was that concerning the time evaluation placed upon the study of Plant Physiology and the four main divisions of the plant kingdom, regardless of the order or method of development followed in the course. For example, quoting the lowest and highest rating for each division we have: *Thallophytes* from 0 to 40% of the course time; *Bryophytes* 0 to 22%; *Pteridophytes* 0.9 to 40%; *Sperma-*

tophytes 3.6 to 83.3%; *Plant Physiology* 0 to 91%. The average evaluations are: *Thallophytes* 19% of the course time; *Bryophytes* 10%; *Pteridophytes* 11%; *Spermatophytes* 37%, and *Plant Physiology* 23%.

One might hastily conclude that this diversity in time allotments reflects the opinions of authors whose textbooks are employed. However, we meet considerable uniformity in textbook selection which indicates that responsibility for the evaluation of these divisions is assumed not by the author but by the individual instructor. Here the geographical locations of the colleges and hence their natural resources also play a part.

Concerning textbook selection it is reported that 40% of the colleges employ the same text. Contending for second place are two other textbooks each receiving a patronage of 10%. The remaining 40% of the colleges place their selection with one of 16 others serving the same field. Among laboratory manuals mimeographed sheets prepared by the department or the instructor are almost unanimously preferred.

That courses are scientifically as well as systematically planned and executed may be deduced from the personnel responsible for such planning. For example, in 70% of the institutions the head of the department together with his associates outlines the courses of study with the approval of the administration. Other practises vest authority in the instructors of the courses or in a Committee on Studies. Direct correlation with other departments is sought by the botany departments of 74% of the colleges. *Home Economics*, *Chemistry*, *Social Service*, *Physical Education*, *Physics* and *Education* head the list of 25 correlated departments.

Student guidance, so popularly advocated today, receives staunch support from botany professors in 88% of the institutions. Many instructors require students to come for conferences regularly but the majority prefer extending such assistance only to students doing work below par or to students who voluntarily seek assistance.

Usually the demand for a subject can conveniently be used as a criterion of success. Judging courses in general botany from this evidence, 72% of the colleges answering this question reported an increased demand among their students, and 26% reported a decline. Others had no estimate or reported no apparent change.

Before concluding, the writer wishes to answer a question

which no doubt has suggested itself to some readers: "To how great an extent have courses in biology replaced those of general zoology and botany?" Biology is taught in 63% of the institutions responding to the questionnaire. In only 12% of the colleges is biology taught to the exclusion of distinct courses in general botany and zoology. Therefore, college courses in general botany and in biology are offered concurrently in 51% of the institutions.

In conclusion, based upon the results of this survey, a typical course in General Botany in a Liberal Arts College for Women, (1) is a year in length, (2) is conducted in separate lecture and separate laboratory periods, (3) requires students to make their own laboratory drawings, (4) includes laboratory quizzes, (5) requires student projects and field trips, (6) is supplemented with various aids to teaching, (7) is outlined by the head of the department with his associates, (8) correlates with other departments and (9) allows instructors time for student conferences.

"REFRIGERATION" OF BODY IS NEW CANCER TREATMENT NOW UNDER TRIAL

"Refrigeration" of the body to a state of "semi-hibernation" is the new method of cancer treatment now being tried at Temple University School of Medicine, Drs. Temple Fay and George C. Henny of that institution told members of the American College of Surgeons.

The "refrigerating" is done by special cooling devices applied to cancer areas, or by X-ray treatment of pituitary, thyroid and sex glands. The latter method reduces the entire body temperature. Object of the refrigerating is to induce a temperature unfavorable for the growth of young cancer cells, which apparently require the high temperatures found in the mouth and internal organs.

In cases in which the method was used to lower the temperature of the area of cancer growth, there was "definite retardation in the growth and decrease in its size in some instances," the Philadelphia doctors reported.

The X-ray "refrigeration" method is used in cancer cases where the tumor cells are widespread throughout the body. Reporting on this method, the doctors stated:

"In one instance, the tumor cells in the brain, spine and bones of the body disappeared and have shown no signs of return, during the past nine months. In two others, definite improvement has been noted in the size of the tumor masses."

The cases had all been given up as hopeless after all regular methods of treatment had failed. Whether the improvement will be permanent cannot be stated at present, but the method is of importance because of the new approach to the cancer problem which it gives.

Important also is the fact that pain was promptly relieved following "refrigeration" of the area of cancer involvement. This alone helped to maintain the patient's strength and morale without the need of narcotics.

Research which led to this new method of treating cancer was financed by the International Cancer Research Foundation.

SCIENCE IN AN INTERMEDIATE CLASSROOM

By Emma C. Johnson
Grade 5A—Loring School, Minneapolis

There are two essentials to the teaching of science—inquisitive minds and question-provoking environment. The inquisitive minds are supplied by any group of children and nature provides the environment, sometimes to a greater extent than at other times. Loring School is unusually fortunate in this respect since it is an outlying school, having in its vicinity two natural lakes, a creek, meadows, and fields.

This environment has been directly responsible for many science hikes, some of which have been of an hour's duration and many of the five and ten minute variety. From these hikes we have brought back a wealth of experience, observations, and specimens for further study. Children have been inspired to bring into the classroom numerous illustrations of Nature's variety of form and activity, providing for an enriched curriculum.

Ryan's Lake, Crystal Lake, and Camden Creek are veritable treasure houses when it comes to stocking an aquarium. Our aquarium has taught us much about water creatures and their needs. We have, at different times, had chubs, shiners, suckers, sunfish, soft-shelled turtles, painted turtles, and several varieties of snails in it. Curiosity has been aroused, questions raised, discoveries made, careful records kept, and conclusions stated. Much has been learned about the inter-relations of water plants and animals.

We have used three types of terraria, the inhabitants of which have aided us in developing scientific attitudes. A large empty paste jar provided a nest for several soft-shelled turtles' eggs, which eventually hatched before our eyes. Snapping turtles, crawfish, and water-bugs have made their homes in these jars. The second type of terrarium is made of two straight-sided cake tins with a cylinder of screen fitted between them. Soil is put in the lower pan. Several varieties of caterpillars, placed in this terrarium and fed in the autumn have held our interest while they spun their cocoons and formed their pupae. After this took place, we transferred them, terrarium and all, to the out-of-doors where they remained until spring. We then brought them in to observe the changes taking place in the

life-cycle of a moth or butterfly. The third terrarium is an aquarium with dirt in one end and water in the other, where such creatures as skinks and salamanders have made temporary homes. By using different types of soil and varying the amount of water, we have brought under closer observation the plant life of woodland, bog, and desert.

Our wild flower garden has been the inspiration for many of our science excursions to the nearby lakes and to the Wild Flower Preserve in Glenwood Park. It has often served as the goal of short trips. It has been one of the largest of our science activities, extending over a period of several years. From a small beginning of three kinds of plants, it has grown to a garden containing forty or more varieties. Needless to say, many an activity has had its beginning along this Nature Trail. Typical of these are the following observations with their concomitant studies: "Most of the early spring flowers seem to grow in the woods," led to a study of the habitat of wild flowers. "Some flowers are much harder to find than others," made the study of plant conservation and propagation natural outcomes. "Some plants do not have flowers," gave us an excellent opportunity to organize the plant kingdom into non-flowering plants (algae, fungi, mosses and ferns) and flowering plants. Many experiments have been carried on with soils, plants, seeds, bulbs, and tubers. One fall a group of children decided to have a wild flower garden in the schoolroom. Several roots were planted in the project table greenhouse. The plants grew for a time but soon withered. In the spring they again sprouted. We wondered if they needed that rest period. Another fall we tried this experiment again, but this time we put the plants outside for a rest period until January. We found they grew much more luxuriantly.

The study of science has developed in our school, not only as a room project, but also as a school or inter-room activity. At one time, a second grade group became interested in the schoolyard trees. They submitted to the fifth grade group questions of identification and tree structure and growth for which they were unable to find the answers. At another time, a first grade group studied cone-bearing trees, during which activity many questions arose, providing study for the two grades. Besides questions arising through group activities, many isolated science problems are referred to the upper grade children for solution. Such experiences have brought about a fine spirit of coöperation.

There is nothing about which children of ten and eleven years of age are more curious than the universe with its order, its vastness, and its mystery of planets, stars, satellites, and meteors. Shadow studies, records, and drawings of the moon's appearance for a month's time, illustrations using the lantern and globe, drawing the constellations or arranging them in the sand-table, modelling the planets according to scale, have all helped to bring about a better understanding of the earth's relation to the rest of the universe.

Wind and weather records kept for a month's time at different seasons of the year have led to other studies. At one time, we became particularly interested in air pressure and properties. Many simple experiments helped us to understand the importance of this factor of our environment.

Through the study of science, the interests of the child may be used to develop habits of learning which give him a background of knowledge and experience basic to his understanding of scientific principles. Science also provides a means for stimulating the child to go to reliable sources of information for facts which he cannot learn by observation and for proof of his own conclusions.

The child must be trained to be observant of all forces and phenomena about him and he must be encouraged to interpret his environment. When we are able to develop desirable scientific attitudes, the problem solving child will be the rule and not the exception.

NEW JERSEY SCIENCE TEACHERS ASSOCIATION

In New Jersey, the science teachers believe in working together. The annual meeting of the New Jersey Science Teachers Association was held at Newark State Teachers College, October 16. At the morning session "A Twelve Year Program in Science" was discussed by Dr. Earl R. Glenn, Chairman of the Science Department, State Teachers College, Montclair. Prof. Wm. McSpadden, Teachers College, Columbia University delivered an address on "Demonstrations in Teaching Science."

Following the general program five section meetings were held: Biology, Chemistry, Elementary Science, General Science, and Physics. In the afternoon the teachers of elementary science continued their section program. The junior and senior high school teachers met at the Newark College of Engineering for an address on "Some of Our Common Problems" by the president of the college, Dr. Allan R. Cullimore. This was followed by a trip through the college laboratories.

THE ADVANTAGE OF USING MACHINES

By L. H. Fuller and T. J. Kuemmerlein
Boys' Technical High School, Milwaukee, Wis.

Introduction

This is a unit of work in ninth grade general science. The student using this guide will find only the key, or more important, points stressed. It is expected that the student will use his own text, as well as other sources of information, in solving the problems. This guide is merely a suggestion as to the topics that may be studied, and it is hoped that it will lead to a more detailed study of others.

The instructor should choose some type of situation or project that is not used in this unit and base his discussion and the class discussion around it. While none of the questions will be answered directly this way, the student will have guidance in answering his problems. If the student makes an honest effort to answer the questions in this, he is bound to have to use some thought and reasoning.

The student should copy the questions and answer them directly in his own note book rather than in this unit. Remember to answer all questions fully and completely.

Problem I. What Do You Do When You Work?

If you have never seen a ski meet you've missed something. The jumper shuffles to the end of the platform, is poised for a second, shoots down the slide before you can gasp, and with tremendous push, jumps up and out from the end of the slide. He flies out above the ground defying the pull of the earth for 100 feet, 200 feet, or more, and then he strikes the ice and snow below. He skims along it for a distance until the grip of the ice on his skis pulls him to a halt. Four forces besides the push of his legs are used or have to be reckoned with.

1. Can you name them?

a. ..... c. .....
b. ..... d. .....

Watch a high diver in the air after he forms the figure of a swan. Down he drops against the air and into the water.

2. What do you call the force of the water that pushes him to the surface?

All matter at all times keeps or changes its position as a result of forces acting upon it; continues its motion when some force effects a pull; or keeps or changes the direction it is moving as some force pushes it. The force may be gravity, momentum, or friction, or buoyancy, or magnetism, or one of the many others. You may say scientifically that *force is a push or pull.*

There are some forces you've felt but never named. Every time you have been riding in a car you have been pushed towards the front as the car came to a stop. You may have been unconcerned with this force at low speeds, but imagine the effect if the stop is caused by a head on collision of speeding cars. You are plunged forward like the man shot from a cannon, and each gleaming knob and surface may puncture or smash whatever it hits. This force was christened inertia by Sir Isaac Newton. He made the most careful measurements and study of it. He said, "Every body in motion will continue in motion unless stopped by an outside force." The people of his day didn't worry about being hit by windshields of speeding cars. He lived in England during the time the American Colonies were being settled. Newton knew that a body at rest was held by a force (called inertia of rest). He found that it took another force to move it. You have seen a performer on the stage jerk a table cloth from under the dishes. If you try it at home, be sure the friction force doesn't overcome the inertia of the dishes or you'll find them in whole or in part on the floor. Why can't you fall out of an airplane as it does an inside loop the loop? While you are traveling straight ahead you tend to keep on going straight ahead, and as the plane lifts, you are forced into your seat. On an outside loop you could be thrown out of your seat like off of a merry-go-round. This sort of inertia is called centrifugal force.

3. Why doesn't the water fall out of a pail as you swing it over your head?

Thus a moving body continues at the same speed in a straight line, and a body at rest remains at rest until an outside force acts upon it. The earth swings around the sun at the rate of some 18 miles every second with one force pulling it away from the sun and another pulling it into the sun.

4. What forces are these?

Find, if you can, the name of the forces that cause or prevent the following:

5. The parachute jumper plunges from the plane. What force carries him towards the ground with tremendous speed as he counts 1....2....3....?
6. What force checks his descent as the parachute is opened?
7. The rocket fuse sputters a moment and with a swish the rocket soars into space. What did the gases do to cause this?
8. The car that travels at a reckless pace on a greasy turn may be forced off the road and against a tree so that the steering wheel cracks the driver's skull like an egg. Can you name that force?
9. Had the car traveled more slowly, the wheels would have been held to the road. Do you know what those forces would have been called?

How is force measured? How much force does gravity exert on you if it exerts 2,000 pounds on a ton of coal and one pound on sixteen ounces of butter or sugar? Your answer would be a third of what it is if you lived on Mars and about one sixth if you lived on the Moon. On the Sun it would be twenty eight times as great.

10. How high can you jump here?
11. With your present strength, how high could you jump on the Moon, the Sun, or on Mars?

Force of one kind or another is necessary for work. *Physical work is accomplished whenever a body is moved.* When snow falls, or iron is pulled to a magnet, or an axe is swung, work is done. In all three cases force has to be exerted and the matter has traveled. Work can be measured. Thus if you lift a ten pound sledge six feet above the ground your ten pound force for six feet gave 60 *foot pounds* of work.

The earth will do some sixty foot pounds of work to bring it down again, and you will add to that to increase the speed and overcome air resistance as you pound on the chisel.

12. How much physical work do you do when you climb a ten foot pole;
13. Jump a four foot fence;
14. Swim 100 yards against a current of combined resistance of fifty pounds;
15. Or chin yourself ten times? Note: (How much do you weigh? How long are your arms?)
16. What do you do when you work?

Problem II. Is Our System of Measurement the Best One Used?

Look over the tables of measurement in common use in the world today and decide which is simpler.

Money

ENGLISH		DECIMAL	
4 farthings	—1 pence	10 mills	—1 cent
12 pence	—1 shilling	10 cents	—1 dime
20 shillings	—1 sovereign	10 dimes	—1 dollar

Length

12 inches	—1 foot	10 mm.	—1 cm.
3 feet	—1 yard	10 cm.	—1 dm.
5½ yards—16½ ft.	—1 rod	10 dm.	—1 M—39.37 in.
40 rods	—1 furlong	1000 Meters	—1 km.
5280 feet—320 rods	—1 mile		

1 inch = 2.54 cm.
mm. = Millimeter
cm. = Centimeter
dm. = Decimeter
km. = Kilometer

Volume

Liquid			
2 pints	—1 quart	10 cl	—1 dl
4 quarts	—1 gallon	10 dl	—1 Liter—1.06 qts.
31½ gallons	—1 barrel	1000 Liters	—1 kl.
2 barrels	—1 hogshead		

cl = Centiliter
dl = Deciliter
kl = Kiloliter

Dry	
2 pints	—1 quart
8 quarts	—1 peck
4 pecks	—1 bushel

1000 cu. cm. = 1 Liter

Weight

231 cubic inches	—1 gallon	10 cg.	—1 dg
2150.42 cubic inches	—1 bushel	10 dg.	—1 Gram
16 drams	—1 ounce	1000 Grams	—1 kg.—2.2 lbs.
16 ounces	—7000 grains		
16 ounches	—1 pound		
14 pounds	—1 stone		
100 lbs. (Eng. 112)	—1 Cwt.		
2000 pounds	—1 Ton (short)		
2240 pounds	—1 Ton (long)		

cg = Centigram
dg = Decigram
kg = Kilogram

1 cu. ft. of water—62.4 pounds

1 cu. cm. of water—1 Gram

Measure the inside of a battery jar (rectangular). Measure it to the nearest eighth of an inch or millimeter.

Use the above tables to determine the dimensions below.

English System of Measurement		Metric System		
Length of Jar	.....ins. .....ft.	...mm.	...cm.	...dm. ...M. ...km.
Height	.....ins. .....ft.	...mm.	...cm.	...dm. ...M. ...km.
Width	.....ins. .....ft.	...mm.	...cm.	...dm. ...M. ...km.
Area of interior base	.....sq. ins. .....sq. ft.	....sq. cm.	....sq. dm.	....sq. M.
		....cu. cm.	....cu. dm.	....cu. M.
Volume	.....cu. in. .....cu. ft.	.....dl.	.....L.	
In liquid measure	...pt. .....qt.			
In dry measure	.....pt. .....qt.			
Weight of like volume of water	.....oz. .....lbs.	.....Grams	.....Kilogram	

If water sold for *1 farthing an ounce* or *1 cent a kilogram* what would it cost to fill the jar?

.....pence .....shilling .....cents .....dollars

1. What, do you think, are the facts that have caused men of the twentieth century to take most of their measurements in the metric system?

Problem III. How Does Man Make Work Easier by Means of Machines?

Simple Machines: Levers

Primitive man had only his hands and muscles with which to overcome the forces of nature. He soon found in his struggle for existence some of these forces too great to be overcome without aid. Man's superiority over animals was revealed when he discovered he could use certain devices to help himself. Thus, machines were invented. Simple and crude as they were at first, they became more complicated and complex. Now, at the present time, it is not easy to see that a machine like the steam shovel is really a series of simple machines. Sometimes man may want to gain strength and power, sometimes gain in distance or speed, or, perhaps change the direction of motion. He then chooses a special machine to help himself. Levers, pulleys, gears, and inclined planes may be used to overcome his difficulties.

1. Why is it that you have to push the jack handle up and down so many times when jacking up a car to change a tire? Why don't you just lift the car up on a block and then change the tire?
2. Why is it very difficult to kill a fly with your hand while if you use a fly swatter you are more apt to succeed?
3. Why does your bicycle have a large sprocket gear on the hanger and a small sprocket on the driving wheel? What would happen if the gears were reversed?
4. Why does an axe split a log when driven into it?

These are a few example of how man uses machines.

When you want to move a heavy log or a stone you use a lever if it is too heavy to be pushed or dragged. A stick or bar resting on some point or support can be used. The point on which the lever turns or rests is called the *fulcrum*. The distance from the fulcrum to the point on which your weight or force is applied is called the *force arm*. The distance from the fulcrum

to the log or stone is called the *resistance* or *weight arm*. It has been found that by multiplying the resistance by its distance from the fulcrum the result will be equal to that obtained by multiplying the force by its arm (neglecting friction). This can be used to advantage to find the values of any one of the four parts of a lever if you have the other three parts. ($F \times F.A. = R. \times R.A.$)

By changing the position of the fulcrum with respect to the force arm and the resistance arm, you will have three different types or classes of levers. Each one will have a special purpose to which it may be put.

FIG. 1. A first class lever.

FIG. 2. A second class lever.

FIG. 3. A third class lever.

The first class lever will have the fulcrum between the force and the resistance. If the resistance arm is short and the force arm long you may move a very heavy object with little force or effort.

The second class lever will have the resistance between the fulcrum and the force. You may want to use this type of lever to overcome a resistance which is to move in the same direction as the force. Wheeling a heavy object on a wheelbarrow is an example of this lever.

The third class lever will have the force between the fulcrum and the resistance. It is used in places where it is desirable to increase the speed of moving the resistance. This type will re-

quire a larger force to be used than the resistance, due to the gain in speed or distance.

5. Name two or more common examples of each type of lever.
6. State why each is used.

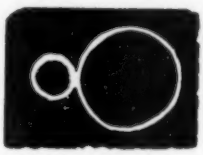
Problem III—Machines: Gears

If you have ever attended an automobile show you probably have noticed that the biggest crowds were always around the cut away models of the new cars. The most fascinating thing about these models is the moving of the various parts by means of gears. Gears are used to reduce the speed of the engine to gain in power; used to transmit power from one place to another; used to make some parts turn fast and some slowly.

Ocean liners use speed reducers to slow down the tremendous speed of the turbine so that the propellors will turn at an efficient rate of speed. Sometimes the reduction is as much as 100 to 1. This means that the small gear on the turbine turns around 100 times while the propellors turn once. With the sacrifice in speed comes a corresponding increase in force. Some of the largest units of this type are made here, in Milwaukee. Pulleys driven by belts, shafts turned by sprockets and chains are simply gears. The chain on a bicycle is a very convenient way of transmitting the effort of the rider to the rear wheel.

7a. In the drawing below, the larger wheel has 5 times the circumference of the smaller. How many revolutions will the smaller make while the larger makes 1 revolution?
7. Why do we turn the large gear on an egg beater rather than the small one?
8. What is the purpose of "low" and "high" on an automobile?

FIG. 4. Gears



Problem III—Machines: Pulleys

Most of you have seen painters working on a building and have observed how they pull themselves up and down. You must also have noticed that the scaffold on which they were

standing was supported by ropes. These ropes run through pulleys. By looking closer you have observed that there were many ropes supporting the scaffold. As it is moved upward you will notice that there is a great pile of rope on the ground, more than enough to reach to the top of the building. Here we have an example of man lifting many times his own weight by his own strength. However, in doing this he is forced to take a great deal of time. By counting the number of ropes supporting the load on each set of pulleys we may estimate the force required to lift that load. This is called the "advantage" and will be discussed later.

Pulleys are used in many ways and places. For example, the flag on a flag pole is hoisted by means of a pulley. This is the simplest kind of a pulley which we call a single fixed pulley. This type merely changes the direction of the force and has no other "advantage." By using a single pulley attached to a load and fastening one end of the rope to a support, we will need only half the force by pulling upward to lift the object. However, it will take twice as long because we have two ropes supporting the load.

9. Why does a derrick use many strands of cable to support the boom which carries the load?
10. How many ropes support the load in the diagrams below?

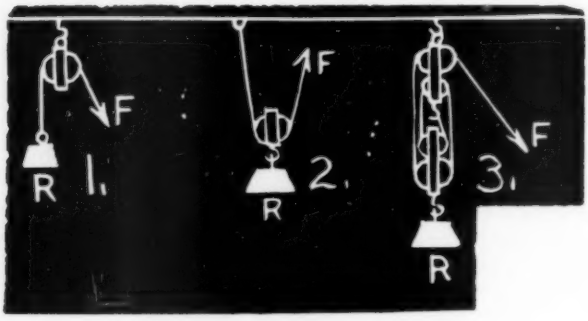


FIG. 5. Three types of pulleys.

Problem III—Machines: Inclined Planes

When you tighten a nut on any part of a machine, you are making use of one of the simple machines—the inclined plane. This very simple little machine makes it easier for us to get objects from one level to another. Rolling a barrel from the ground up on to a truck requires less force than lifting it, but

the distance it is rolled is greater than the distance it needs to be lifted. Any screw, nut, or bolt is an inclined plane. Even the lead in your automatic pencil is pushed forward by an inclined plane.

11. List five machines that make use of the inclined plane.

Problem III—Machines: Mechanical Advantage and Efficiency

To put our information about machines to work for us, we must know what we can gain by using them. You may well ask, "What is the advantage of using this machine? How much does this machine increase my speed or force?" If in lifting a heavy object by means of a lever or pulley you can lift several times more than you could without it, then that number of times is called the "advantage." This can be expressed as a relationship between the resistance and the force or between the force distance and the resistance distance.

$$\text{Advantage} = \frac{R}{F} = \frac{\text{Force Distance}}{\text{Resistance Distance}}.$$

The amount of work done by a machine divided by the amount of work put into the machine expressed in per cent, is called its efficiency. No machine does more work than is put into it. In fact, we never get out as much as we put in. Therefore, because of friction and other losses a 100% efficient machine is impossible.

12. List various facts you have to know in order to determine the efficiency of a locomotive.

Problem III—How does man make work easier by means of machines?

Directions: Choose one of the following machines as the basis for the work on this topic. Cut out a picture or make a drawing of the one you choose and place it in the space below.

A. Types of complex machines
   1. Steam Shovel
   2. Automobile
   3. Bicycle
   4. Pile Driver
   5. Elevator
   6. Airplane
   7. Machines used in the home

B. Drawing or picture

C. Make drawings showing where each type of simple ma-

chine is used in your project. Label all parts such as fulcrum, force, etc.

D. Answer these questions regarding your machine
   1. What work does his machine do?
   2. Why do we use this machine?
   3. How would you determine the mechanical advantage of each type of simple machine used in your project?
   4. How can you determine the efficiency of your machine?

Problem IV. How Is an Engine a Transformer of Energy?

" 'My good lads shoved me off and the *Bluebird* made a good getaway in first speed. . . . Ahead of me stretched a seemingly illimitable field of glaring white with an eight-inch black strip down the center to guide me . . . Faster and faster I went. It was the first time a world's high-speed record had been attempted on salt . . . I passed my first marker, a huge "No. 6" three feet high, painted on a large square board. This indicated to me that I had six miles to go before I reached the beginning of the measured mile . . . I passed Nos. 5, 4, 3, 2, 1 . . .

" 'I tried to steal a quick glance at my revolution counter. It was well over 3,400 revolutions per minute. I knew I was running 300 miles per hour . . .

" 'On I went out of the measured mile. I shut off my engine to get its braking effect on the car. Could I stop in the six miles left to go?'

"Sir Malcoln managed to stop but before he did so, he had a blowout."

" 'It made a loud pop . . . I felt a jar on the front of the car . . . I saw bits of rubber fly up from the left front tire. The salt flying up into my face had by now almost stopped vision through my goggles. I swerved out of line. I snapped the "old lady" back quickly and there wasn't much trouble in the run to the stop. . . . ' " *Time*, September 16, 1935.

Let us stop with Sir Malcolm Campbell and examine this marvel of science to see what makes it go.

Let us look under the hood at the 2,500 H. P. engine which enabled him to drive six tons of machinery 300 miles per hour. It has twelve cylinders into which a mixture of air and gasoline is forced by the air pressure and a supercharger. This mixture trapped in the cylinder because the intake and exhaust valves are closed, is compressed to 100 to 200 pounds per square inch

when a spark from a spark plug ignites the mixture, causing it to burn and expand thus producing the tremendous force. The return of the piston forces the used mixture out of the exhaust valve thus completing the four strokes of this engine. This process is repeated for each of the twelve cylinders thus changing or transforming the stored up or potential energy of the gasoline into kinetic energy or energy of motion.

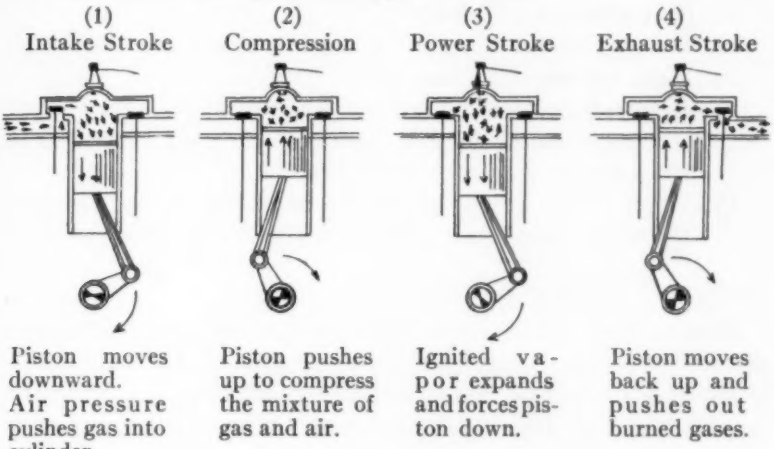


FIG. 6. Four cycle gas engine.

1. Gasoline is spoken of as a fuel. List as many facts as you can that reveal its likeness to coal.
2. Notice the diagrams of a four cycle engine and write the names of the *4 strokes in proper order*.....
   .....
3. What mechanical part of the four cycle engine corresponds to the fuel door of a stove?
4. What forces the gas up into the cylinder?
5. What human process is similar to the intake stroke?
6. What gas is taken from the air, in the burning process in the cylinder?
7. Why does the gas not escape when compressed in the cylinder?
8. What part of the gasoline engine serves it as a match serves a stove fire?
9. What fact shows gasoline to have a lower kindling temperature than coal?
10. What force pushes the piston down to give energy to the wheels?

11. How are the waste products removed from a gasoline engine?
12. What waste products are removed from the human system in a similar manner?
13. What waste products are produced in the gasoline engine?
14. Can they be produced by other combustion processes?
15. To what waste products of the human system do they bear strong resemblance?
16. What doorway must be opened to allow the wastes to leave the gasoline engine?
17. If stored energy is called potential energy and energy of motion is named kinetic, how is the former converted to the latter in a gasoline engine?
18. What other energy makes it necessary to have water circulate around the cylinder walls of most automobiles?

Problem IV—Engines: Diesel

Many of you will recall the startling records made by the new streamlined trains; how speed record after speed record has been broken by them. Some of these records were broken by the new lightweight Diesel powered trains. Here we have a train powered by an oil burning engine which drives an electrical generator which in turn supplies electricity to the driving motors. These engines use the same kind of oil that you might burn in the oil burner in your home. The Diesel engine may use the same four cycle principle of the gasoline engine. Instead of taking in a charge of air and gasoline, this engine is filled with pure air on the charging stroke. The air is compressed by the piston to a pressure of 500 pounds per square inch in raising its temperature to 1000°F. At this point (the top of the compression stroke) a small amount of fuel oil is sprayed into the cylinder where it burns instantly because of the high temperature caused by the compression. The burning and expanding of the gases produce the power. The rest of the cycle is the same as that of the gasoline engine. Here we have an engine transforming into kinetic energy the potential energy of oil, which the sun stored up millions of years ago. We see the converting of the chemical energy of burning fuel into heat energy which results in mechanical energy.

The advantage of the Diesel engine lies in its high efficiency and its ability to use low cost fuels. Also the elimination of spark ignition system is an advantage.

19. How is the oil temperature in a Diesel engine raised to the kindling point?
20. This method of kindling the oil makes unnecessary what system that is so vital to the gasoline engine?

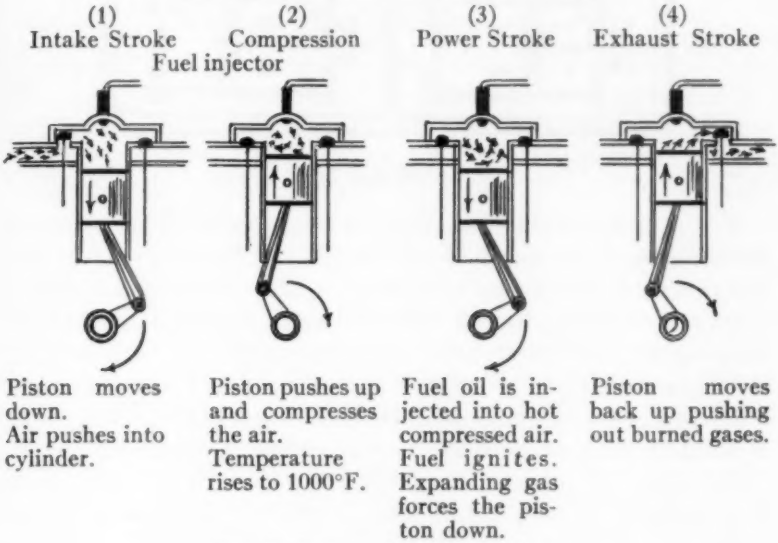

(1)
Intake Stroke
(2)
Compression
Fuel injector
(3)
Power Stroke
(4)
Exhaust Stroke
Piston moves down. Air pushes into cylinder.
Piston pushes up and compresses the air. Temperature rises to 1000°F.
Fuel oil is injected into hot compressed air. Fuel ignites. Expanding gas forces the piston down.
Piston moves back up pushing out burned gases.

FIG. 7. Four cycle Diesel engine.

Problem IV—Engines: Reciprocating Steam Engines and Turbines.

If you take a small vessel with some water in it, cork it lightly, and heat the water to the boiling point, you will soon see the cork fly off with a loud report. The heat energy you applied to the water was transformed into mechanical energy in the flying cork. Harness this energy so that the operation can be repeated rapidly and you will have a steam engine.

In many respects the steam engine is similar to the gasoline engine. Both have pistons and valves, and both make use of the expansion of some gas. In a reciprocating steam engine, one in which the piston moves back and forth, the power of the expanding steam is applied to both sides of the piston which makes it more flexible than any other type of engine.

The steam entering the cylinder is controlled by a slide valve in a steam chest. This valve allows the steam to enter first on one side of the piston and then on the other. The power is then transmitted through the piston rod and connecting rod to the driving wheels or crank shaft.

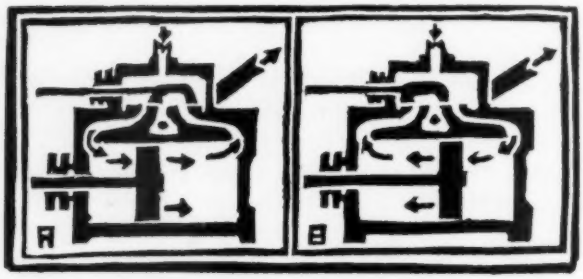


FIG. 8. Reciprocating steam engine.

In the steam turbine we find the steam pushing little curved blades around on a number of wheels on the same shaft. The steam first strikes a row of blades on the wheel, then a row of stationary blades, then a row of blades on the wheel again, keeping this up until most of the power of the steam is used.

Engines of this type must run at high speeds to be efficient. Therefore, their use is limited to places where this kind of power is wanted, such as generators, continuous pumping, and ships. This is also one of its disadvantages in that the turbine speed may have to be reduced as we pointed out in Problem III on gears.

Problem IV—Engines: Steam

21. You will notice that the valve in the steam engine diagram is not labeled exhaust or intake as in the gasoline or Diesel engine diagrams. Why would such labels be impossible in the steam engine diagram?
22. How does the steam engine differ from the gasoline and Diesel engine in the number of power strokes?
23. The steam engine requires a boiler and a steam chest while the gasoline engine requires an ignition system and a carburetor, and the Diesel engine a fuel injector. How is the energy in the fuel released in each case in the chart below?

	When is fuel combined with oxygen?	How is fuel heated to kindling temp.?	What produces the power to push piston?
STEAM			
GASOLINE			
DIESEL			

24. The simplicity of the steam turbine which is easy to build, repair, and maintain should make it a good power plant for the motorist. What sort of device will have to be invented before we can use the turbine in an automobile.

Problem IV—Engines: Electric Motors

After creating electrical energy by means of a water turbine driven generator or steam driven generator (mechanical), or by a battery (chemical) we must have a way of using it. The electric motor is the device that changes the electrical energy into mechanical energy.

Because an electric current will produce a magnetic field of force when flowing through a wire, it can be made to do work. This magnetic field will produce electromagnets which in turn will attract or repel other magnets. This is one kind of electric motor. By means of an armature, field magnets, brushes, commutator or slip rings we may transform this electrical energy into continuous mechanical energy.

Problem IV—Engines: Water Power

If suddenly the sun were to cease to shine for any great length of time, not only would the people on this earth suffer from cold and hunger, but they would lose millions of horsepower of energy. This energy, which might be used to prolong their lives, would be lost. The snow on the mountain tops would not melt, and as a result there would be no water to turn the water wheels. Since the water behind a dam or in a swiftly flowing stream has potential energy because of its position, it can be made to do work. This energy of this position (potential) can be transformed into energy of motion (kinetic) by means of water wheels. The old mill by the side of the stream with its picturesque water wheel is now replaced with an efficient turbine. By conducting the water from a higher level to a lower level the weight and force of the water turns the curved blades on the turbine wheel. The turbine shaft in turn drives the electric generators. Again we have the sun as the source of the energy. We also have the transforming of potential energy into electric energy, into heat, light, chemical, and mechanical energy in our homes and factories.

25. A storage battery is charged in a Milwaukee garage using alternating current in a charger. It is then used to start an automobile. Point out each energy conversion in the

chain that extends from the power reservoir, containing water put there by the sun, to the kinetic energy of the automobile's flywheel.

Projects and reports

Prepare an oral or a written report on any of the following topics.

1. Perpetual motion schemes.
2. The power plants in the new *Normandie* or *Queen Mary*.
3. The life and work of Sir Isaac Newton.
4. The life and work of James Watt.
5. The life and work of Thomas Newcomen.
6. The new streamlined trains.
7. Report on the "tide engines."
8. Report on the T. V. A.

Projects.

1. Model steam engines
2. Model steam turbine.
3. Devices to show centrifugal force.

METHODS OF LOCATING SALT-WATER LEAKS IN WATER WELLS

In localities where highly mineralized water is present in beds above and below the beds that yield the supplies of fresh water it is necessary to be able to locate leaks in wells in order to know whether the wells are being contaminated through holes in the casings or whether the fresh-water supply is failing. In view of the great value of many potable water supplies that may be destroyed if they become contaminated by salt water, the importance of methods of locating sources of contamination cannot be overestimated, as the information obtained from surveys of salt-water leakage makes it possible in many areas to take remedial measures to protect the fresh-water supply.

The Geological Survey, United States Department of the Interior, has issued a report by Penn Livingston and Walter Lynch as Water-Supply Paper 796-A on methods of locating salt-water leaks in water wells to meet the demand for information on this subject. Copies of the report may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C., for ten cents each.

The report discusses four general methods of detecting salt-water leaks, known as the pumping method, the velocity method, the sampler method, and the electric-conductivity method. The equipment is described and the results obtained from the use of the various methods in areas in Florida and Texas are reviewed.

THE EXHIBIT AS A SUPPLEMENTARY METHOD —II. FORMS OF CALCIUM CARBONATE

By Harold J. Abrahams
Simon Gratz High School, Philadelphia, Pennsylvania

A previous article in School Science and Mathematics[1] discussed the use of exhibits as a method of presenting instructional material otherwise crowded out of the science curricula of high schools. Not only to widen the applicability of this method, but also to maintain student interest, the suggestion was made that exhibits be replaced frequently. In harmony with this idea, we present the results of a second project along these lines.

Calcium carbonate occurs in great abundance in such a wide variety of forms as to be a source of never-ending wonder. Some of these forms have properties which are either unique, "mysterious," or intriguing. Teachers can easily recall the open-eyed amazement of young students when they first realize that dull, apparently shapeless chalk, glistening crystals of marble, transparent, doubly refracting calcite and various marine shells are, in the main, chemically identical. The ease with which its varieties can be used to emphasize the fact that different forms of the same chemical compound may possess widely contrasting properties therefore makes calcium carbonate an ideal subject for treatment by the "exhibit" method.

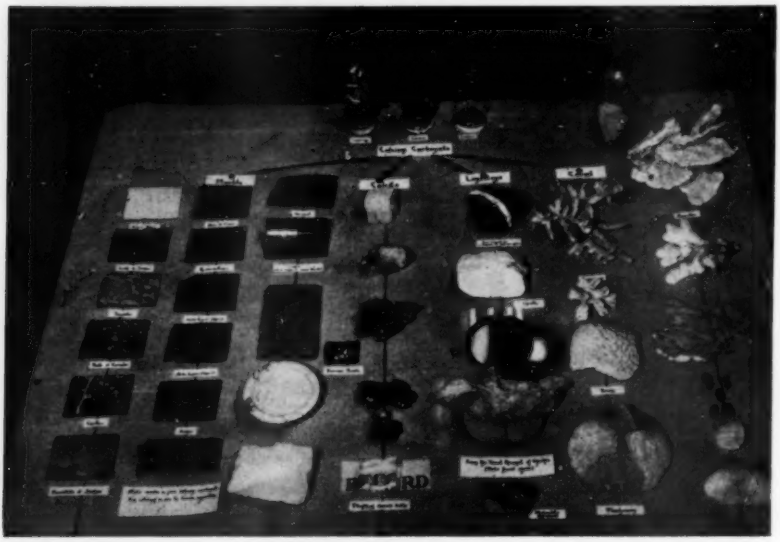
The present exhibit was set up in two museum cases as follows:

Inverted specimen jars containing bright calcium shavings, powdered charcoal and oxygen gas respectively were placed at the rear of each of the two cases. From a card, bearing the words "Calcium Carbonate," in front of each set of the three elements, red ribbons led off to cards bearing the captions "Marble," "Calcite," "Limestone" and "Coral" in Case I and "Eggs," "Mollusks," "Crustacea," "Echinoderms" and "Protozoa" in Case II. From each of these nine headings, a red thread ran to the front edge of the case and along these threads were placed the appropriate specimens exemplifying the captions. Thus location of a specimen either upon or near a thread classified it at once for the observer as belonging to the main division indicated by the caption at the top of the thread. The

[1] "The Exhibit As A Supplementary Method—Crystallography," December 1936.

specimens in the two cases were thus divided in the main according to whether they had their immediate origin in the inanimate or animate world.

Small tags were prepared for those specimens having specific names or unusual interest. In Case I, for example, a specimen of limestone taken from the Great Pyramid of Cheops, near Cairo, was so labelled, and its marine shell origin emphasized by placing a magnifier above it to facilitate inspection. A piece of newsprint was placed under the specimen of doubly-refract-



CASE I

ing calcite, to draw attention to its unique property. Near this specimen was a card bearing the words "Everything appears double." A card under the "onyx" read "Real onyx is silicon dioxide." Among the corals one specimen was unusual. It consisted of a coral growth upon a glass bottle found on the beach at a seaside resort.

The specimens in Case II were intended to make association in the students' minds between calcium carbonate and its use by living forms. To introduce a note of variety and thus overcome too evident repetition, the egg division was made up of a series of eggs graduated in size, from the gigantic one of the ostrich to the small one of the turtle. Specimens in the mollusk division, which attracted much attention and elicited comment,

were a piece of "mother of pearl" with perforations showing where buttons had been punched from it by a machine, a necklace made of marine snail shells and a long oyster shell to which numerous smaller shells were attached. Three small crab molts under the crustacea caption stimulated much interest, as did the exoskeletons of several small crayfish. The calcareous remains of a very tiny king crab amused many students. As an additional attempt to implant some idea of the important role played by minute living forms in building up vast inanimate

CASE II

things, a microscope focused upon Fusilina was placed under the Protozoa caption, next to a specimen of "limestone in process of formation."

The beauty of form and color attainable by such a collection of mineral and marine specimens must be left to the imagination. The accompanying photographs[2] will give merely an idea of the arrangement of materials. Above the exhibit was placed a typewritten plaque reading as follows:

"A Various Language"

Nothing in the wildest imaginative writings of man is more surprising than Nature's cunning. From the same substance she can fashion both living tissue, too small to be seen by the naked eye, and ridges of limestone, so

[2] Grateful acknowledgment is herewith made to Mr. Mark H. Hagmann of our Mathematics department for the accompanying photographs.

immense as to be visible at a distance of many miles. Her art enables her to build yesterday's living matter into submerged mountains of coral, upon which large ocean liners often dash themselves into bits. Yet she can use the same material to a more kindly purpose—in her concern for the pain of one of her creatures, the lowly pearl-oyster, she sends forth a fluid to relieve the irritations caused by a grain of sand. Thus is formed the highly prized pearl.

Often she fashions tiny shells of the same chemical substance, and then builds these into mounds so broad and high that they become vast land areas, when the ocean recedes. The white chalk cliffs of England, which, because of their color, caused the ancients to call that country Albion, were formed in this way.

Chalk and pearl, . . . coral and marble, . . . microscopic Foraminifera and gigantic hills of travertine, . . . egg shell encasing life and limestone pyramids enclosing the dead remains of the "late" Pharoah Cheops, . . . reefs to destroy man and caves to shelter him . . . living, moving creatures and inanimate, transparent calcite . . . behold the real Jekyll and Hyde!

* * *

Everything shown in these display cases is calcium carbonate, a compound consisting of one "part" calcium, one "part" carbon and three "parts" oxygen. Calcium carbonate is, next to quartz, the most widely distributed of all minerals. When we consider the great variety of forms which calcium carbonate can assume, we do not wonder that a great man has written:

> "To him, who in the love of nature holds
> Communion with her visible forms, she speaks
> A various language . . . "

List of Materials in the Exhibit

Case I

Specimens of Calcium, Carbon and Oxygen

Marble

Bianco Antico
Giallo di Sienna
Bandillio
Misto di Carrara
Cipollino
Broccatello di Spagnia
Blore di France
Rosso de France
Porta Venere (Type I)
Porta Venere (Type II)
Mishio
Vermont
"Onyx" (true onyx is silicon dioxide)
White Marble
Black Marble
Yellow pink veined
Marble dish

Calcite

Opaque
Doubly refracting
Dog Tooth Spar
Three other crystalline varieties
Travertine
Aragonite

Limestone

Blue Limestone
Chalk (lump and stick)
Piece from the Great Pyramid of Cheops(—fossil shells)
Stalicite (polished)

Coral

Branching—several varieties
Brain
Mushroom—two varieties
Propeller
Carved Coral jewelry

Case II

Specimens of Calcium, Carbon and Oxygen

Eggs

Ostrich
Pheasant
Hen
Turtle
Wren
Canary

Mollusks

Abalone shells (2)
Oyster—shell
Land snails
Clam shell
Mussel—shell
Mother of Pearl (holes punched through)
Razor clam
Conch shells
Marine snails
Scallop shell
Coquina
Baroque Pearls

Crustacea

Crab molts
Edible blue crab
Lady crab
Fiddler crab
Hermit crab
Crayfish
Barnacles
Spider crab

King Crabs

Small and large

Echinoderms

See urchin (spines removed)
Sea urchin (with spines)
Sand dollar
Starfish
Brittle star

Protozoa

Loose shells before formation of rock
Limestone in process of forming
Fossil Fusilina
Slide of Fusilina under microscope

The most pronounced reaction evoked in the majority of students by the exhibit was a gratifying appreciation of the beauty of form and color possessed by the biological portion of the exhibit. To those who may have failed to grasp the main objective of the exhibit, the aesthetic appeal appeared sufficiently strong to have justified the experiment for this indirect influence upon them. The more thoughtful students expressed surprise at discovering a relationship between the realms of the animate and inanimate. Others were surprised to find that certain familiar marine forms belonged to one phylum rather than to another, leading to the thought that exhibits might aid in presenting phyla in the study of zoology.

GLACIER

Great forests wiped out by glaciers only a few thousand years ago have just been uncovered by a small recession of the Alaskan coastal glaciers, according to findings reported by William S. Cooper, University of Minnesota glaciologist, in the *Geographical Review*. Shortly after the last great ice age, which ended only 20,000 years ago, the ice receded far up the valleys on the Alaskan coast, and great forests grew up on the well-watered valley floors. A period of cooling only a score of centuries ago caused a glacial readvance, and the forests were buried under frozen gravels and ice. Recently, the ice has melted, and the stumps of these ancient forest trees are again exposed to the air. This recent retreat began only about 200 years ago, according to evidence supplied by rings in trees growing on the glacial deposits.

A SIXTH GRADE UNIT ON PERU

By Anne M. Goebel
The Kansas State Teachers College, Emporia, Kan.

Pupils enrolled in the geography classes of the Laboratory School of the Kansas State Teachers College during the summer session are allowed under guidance to select countries for study in which they have particular interest or those with which they have had no class-room contact. During the summer session of 1935, it was discovered that several members of a sixth grade were in school, not because they needed remedial instruction, but because they had an interest in the various kinds of work offered. This being true, it was considered inadvisable for the pupils of the grade to study countries of Europe or Asia—those generally considered in the sixth year—as some of the countries had previously been studied or were to be the following semester. Under the circumstances, Latin American countries offered the greatest possibilities.

After a detailed study of Mexico, a brief stop made in Central America was followed by a trip through the Panama Canal. It was then decided to reach Chile by moving southward along the western coast of South America. Brief visits were made at Buenaventura in Colombia, and at Guayaquil in Ecuador before stopping at Tumbez and Talara, Peru, adjacent to the boundary of Ecuador. At both of these places, oil derricks dot the desert. The former is the outlet for the Lobitos field, while the latter, where there is a large refinery, is from the Negritos. Other fields producing are the Zorritos and the Laguintos. Oil production in these fields, though not spectacular in nature, is steady, and the oil is of a good quality. This product is the chief export of Peru today. A very good picture of an oil refinery of northern Peru is given on page 201 of *North and South America*, by Bodley and Thurston. Before leaving this oil producing area, the pupils decided that greater development in the way of working the coal, copper, gold, and silver mines might also be possible.

On the longer visit made at Paita, waste land similar to that mentioned above was recognized. On this fifty to eighty mile coastal strip in Peru, vegetation is scanty everwhere except in the river valleys fed by the mountain streams. The sterility of this land was understood on learning that for periods as long as ten years there might be no rainfall.

Plans for further study as outlined by the pupils included a consideration of activities at Paita, a short trip interior to Piura on the Piura River and even an imaginary trip to Iquitos on the Amazon River, where they crossed the Andes that are relatively narrow in this part of the country.

On arriving at Iquitos, located in a third of the natural regions of Peru, they found it in a tropical area. Rubber, cinchona, coco, and other medicinal plants, scattered in the forests along the river and along the winding pathways, bring little return to the Indian gatherers. These products are displayed in markets like the one pictured on page 41 of *South America*, by the Chamberlains. Many of the natives in this part of Peru are in a more or less low stage of civilization. They live in poor huts where they are worried by insects. They chew coco leaves while they hunt with the blow gun. River steamers reach Iquitos from the Atlantic but due largely to the long haul they are few and far between. Contact of these natives with the outside world will be increased if and when, sometime in the future, a railway is built toward the Pacific over the mountains through Piura and to Paita, a distance of nearly five hundred miles. After tabulating the impressions gained about the eastern part of Peru before leaving the Amazon valley, the pupils were interested in listening to sections from two articles: "East of the Andes" by William Llewellyn on page 61 of the *Pan American Bulletin* for June, 1931, and to "A Botanical Trip to Eastern Peru and Amazonia Brazil" by Ellsworth P. Killip and Albert C. Smith on page 997 of the October, 1930, issue of the same publication.

Since at the outset members of the class had decided that their interests in northern Peru were chiefly in the coastal area, they returned to Piura, the settlement largely responsible for the life and growth of Paita. The life of the people here is closely associated with their position along the Piura, a river honored by special feast days. Since rain rarely falls, settlers upstream send word to those down, letting them know when high waters are likely to reach the town. The villagers march in a body to meet the water of "The Nile of Peru."

The pupils followed the Piura Valley across a more or less lifeless plain as they went from Piura to Paita, one of the twenty some commercial ports on the Pacific. They found that the prosperity of dirty struggling Paita with its fairly good harbor is largely dependent on Piura. Built on the sand-hill lined

bluff it is a typical desert port on the Pacific. There is an air of business about the town even though the desert is so sterile. Vegetables, cotton, and Panama hats in the market place interested the pupils. The latter are made from jipi japa grass or from toquilla leaves. The leaves are taken from the palm trees, tied into bundles and sold. Since they are broad they are split for weaving. Much of this work is done during spare time. The better hats however are woven very early in the morning or at night time when evaporation is not so great. The value of a hat depends very largely upon the number of rings in the crown. Nine rings make a very ordinary hat while one having as many as eighteen is a DeLuxe model. Men often come on board the ships as they enter the harbor offering these very flexible hats at twenty five dollars each. Later when sales lag they may be reduced to ten. There is a short section on page 69 of *South America* by Harry A. Franck on "Making Panama Hats" that was enjoyed by the pupils.

Many of the ideas given in the preceding paragraph were learned through reading from *South America* by Isaiah Bowman, Chapter VI, pages 91 to 96 inclusive; and *South America Today* by Rufus Austin White, Chapter VII, pages 86 to 92. The article "Reclamation Projects of the Government of Peru" by Walter Manger in the *Pan American Magazine* for May, 1930, was also read.

After making a hurried summary of the activities in northern Peru, the next objective of the class was to plan for the trip toward Callao. The members of the class suggested what might well be found along the narrow coastal strip. Except along the valleys fed by reddish mud laden water there would be but little vegetation. At times the pupils surmised that a gray mist might hang over the hill-tops but that in general the description given by one writer of the "thirsty" Andes as the clothes wringers of nature held true. The winds from the east absorb quantities of moisture as they cross the ocean. When they are cooled, the moisture is lost on the windward side of the mountains. The position of Peru as to latitude does not favor rainfall from the west. Mr. R. A. Whitbeck in his article "The Coast Waters and Coast Lands of Peru" in the *Journal of Geography* for February, 1926, reported that in 1925 a warm current crowded between the northward sweeping Humboldt current and the land, leaving moisture. Ocean waters off of a part of the coastline of Peru in latitude twelve degrees south were as cool as those of

New York City, in latitude forty-one degrees north. These cool waters, teeming with life, no doubt had their influence on the early economic history of Peru.

As the pupils traveled southward they noticed that the coastal strip was more or less bare except where water provided through irrigation helped the plants to flourish in a more or less miraculous fashion. Products sent from the interior settlements along the streams to ports having poor harbors help to keep the cities alive. Before making a detailed study of agriculture along the coastal plain of Peru questions arose as to the products grown and reasons for their growth. Maps on page 24 of *Southern Lands* by Barrows and Parker show sugar as well as cotton production. Those on pages 99, 100, and 101 in *South America* by Isaiah Brown show irrigated areas, one of the largest districts being near Trujillo. The pupils studied the picture on page 365 of *American Lands and People*, by J. Russell Smith, as well as similar ones. They also read short sections from many references. After having made rather careful investigation of the material available, a general "pooling of ideas" followed. The pupils agreed that many sub-tropical crops coming on throughout the year could flourish if water in sufficient quantities were available. More than fifty per cent of the agricultural capital of Peru is in the irrigated sugar cane farms. There is more money invested in sugar than in any other agricultural product. According to R. H. Whitbeck, it costs about two cents a pound to produce sugar and it sells for three cents a pound.

Cotton, a crop that thrives in the valleys where there is no frost, is the second most important crop. Under ideal water control it does well. A single crop of high grade cotton that spins in nicely with wool since it has a crinkly fiber, may yield more than a crop in the United States. In certain years, two crops may grown in a season. The time of planting and harvesting is no doubt determined more by the water supply than by the temperature. People are likely to plant cotton when the rivers are high and cut it when they are low, which is generally from March to September. In certain valleys, however, you find it being planted and harvested at the same time of the year. A very interesting thing about the growth of cotton on ground that is barely scratched, is the fact that it grows from ten to fifteen feet in height and that it may produce for several years on land that is fertilized.

Guano is a type of fertilizer commonly used. It may be the remains of fish left on the islands along with the excrement from birds. The surface of the sea and the islands were no doubt at one time alive with birds. It is reported that at certain times there were as many as a million on a single island. These were of different kinds. Cormorants, pelicans, and gannets are the most numerous today. A picture of guano producing birds is shown on page 148 of *From Panama to Cape Horn* by Edith Salisbury and on page 88 of *Southern Lands* by Barrows and Parker. Page 102 of *Economic Geography of South America* by R. H. Whitbeck includes a paragraph on the guano deposits.

Agriculture in the coastal area shows little change as progress is made toward Callao. It was learned that there is a tendency toward large plantation holders absorbing small farmers. Thirty of the large estates now produce sugar that is greater in value than the products from the copper mines. Ownership by whites who employ peons at a low wage is gaining ground. The peons are housed in poorly constructed huts having mud floors and little or no furniture.

In due time the city of Callao was reached. This city, established a few years after Lima, has been partially destroyed by earthquakes on several occasions. Callao, a cosmopolitan city of 50,000, has one of the few harbors along the coast that has been partially developed. Breakwaters have been built into the open bay. Fairly large boats may dock next to the land where lighters help with the unloading of ships from many parts of the world. A great many general products are sent through Callao. The value of the imports is less than that of the exports. Trade for the country as a whole is not large since the demands of the Indians and Mestizos who make up about ninety per cent of the settlers are not great. They produce few things that enter into the trade of the country over the limited routes of travel. Of the hundred million dollars worth of products exported in a recent year, sugar, cotton, oil, and copper made up eighty per cent of the total. Two-thirds of the total exports went to great Britain or came to the United States. Callao receives more of the imports than the combined totals at the rest of the ports. There are in the city cotton ginners and spinners, wool weavers, tanners, flour millers, and rice polishers. The centrally located port of Callao is shown on page 108 of *South America* by Harry A. Franck, page 6 of the *Pan American Bulletin* on Peru, page 366 of *American Lands and People* by J. R. Smith, 243 of

Our World Today by Stull and Hatch, and 203 of *North and South America* by Bodley and Thurston.

The trip from Callao to the city of Lima seven miles up the Rimac River showed possibilities for both power and irrigation. Crops were found growing abundantly. Cattle are fattened on the forage grown and milk is sold from door to door in the city. The pupils now understood why the Rimac is called by the Indians "The River that Speaks." Power generated by the river gives light and energy, it also furnishes the water supply, and it is believed by many that it helps temper the climate of the city. The city of Lima however with its mountainous background is always cool enough to cause the people to want a fire but never to make them build one. The pupils learned that there is a great deal of cloudy weather. About half of the daylight hours are cloudy but there is little rainfall.

People living in the city of Lima—the capital of all of South America for three hundred years—are very definitely of two classes. Where the cultured live more or less in luxury, the poorer people live in mud walled huts with poles supporting the roofs. In general, the yards with their flowers are beautiful. People work in a leisurely fashion, resting from seven to eleven and from one to six. They may be seen on the narrow balcony-lined streets. The University of Lima was established in 1551, sixteen years after the city was founded on the site of an Indian village. The founder Pizarro was killed at the age of seventy while seated at dinner. It is reported that the body of the cruel adventurer later appeared mummified in a glass case in the cathedral. References on this city of 250,000 are found in practically every book on South America. Page 257 of *Seeing South America* by Guitteau and Winter, 87 of *Our South American Neighbors*, by Gertrude Southworth, 104 of *South America* by Isaiah Bowman, 96 of *South America Today* by Rufus Austin White, 42 of *South America* by the Chamberlains, 102 of *South America* by Harry A. Franck, and Chapter XI of Carpenter's book were read by various members of the class. Pictures of the "city of the kings" in most of these books gave further understandings of Lima.

After a rather detailed study of Lima, the next objective was to visit the mines at Cerro de Pasco going by way of Oroyo. It is about a hundred miles to Oroya from Lima and another hundred to Cerro de Pasco. The description of the trip beginning on page 103 of *South America Today* by Rufus Austin White is

fairly good. Pages 107 and 108 of *South America* by Isaiah Bowman gives a description of the trip as well as of the mines. "A City of the Sky" on page 96 of *South America* by Harry A. Franck is worth reading. So also are chapters XII and XIII in *South America* by Frances Carpenter.

The Central Railway leading from Lima to Cerro de Pasco through Oroyo is considered one of the most remarkable pieces of railway engineering in the world. It is not a cog road even though it reaches a height of more than 15,000 feet. A trip over it is more impressive than the one over the St. Gotthard Road in Switzerland since the tracks are higher. A section of the road is well pictured on page 465 of *Our World Today* by Stull and Hatch, page 90 of *Our South American Neighbors*, by Southworth. Fairly interesting comments on the railways are given in the *States of South America* by Charles Domville Fife, in *South America* by Clarence Jones, in *Republics of Central and South America* by C. Reginald Enoch and in *Economic Geography* of South America by R. H. Whitbeck.

Cerro de Pasco is 14,300 feet above the sea; it is difficult to breathe rapidly enough and headaches may result in reaching this height. Some of the highest dwellings in South America are nearby, while there are shepherds' huts located at a height of 17,000 feet. These mountain dwellers have done but little to improve the breeds of livestock that feed on the wiry grass. Barley and potatoes are grown on the terraces that reach about to the snow line. Crops of wheat and corn are found in the valleys, the latter ripening at a height of 12,000 feet. Pages 79 and 87 of *Southern Lands* by Barrows and Parker describe valley farms some of which were seen on the way to Cerro de Pasco.

The mines at Cerro de Pasco are owned and operated by American capital. About a hundred-fifty Americans as contrasted to twelve thousand natives work in these mines. The few conveniences inside the dingy dark huts of the latter are quite in contrast to the modern machinery used in the mines that produce not only nine-tenths of the copper that is largely smelted at Oroyo but also gold, silver, quicksilver, and vanadium used in the steel industry. In recent years Peru has ranked about third among the countries of the world in the production of silver. A picture of a silver mine is shown on page 131 of *South America* by Isaiah Bowman. Mineral products may bring $50,000,000 annually, an amount exceeding in value the agri-

culture products. The Commercial *Year Book* shows that there has been a decrease in mineral production from $147,321,000 in 1929 to $35,940,000 in 1931.

The objective after having summarized the work on mining was to proceed southward from the mines of Cerro de Pasco toward Lake Titicaca. The group was interested in retracing its way in part over the railway with its sixty-seven bridges, its sixty-five tunnels, and its sixteen switchbacks. On careful observation the pupils understood why the cost reached to as much as $200,000 a mile. Some money was borrowed from the British for the construction but now the railway is controlled by a Peruvian corporation aided by the government when there are deficits in operating costs.

The trip into the Huancay country where the novel woven bridges were seen was a change. Such crossings are shown in the frontispiece of *South America* by Nellie Allen, page 47 of *South America* by the Chamberlains, and 164 of *From Panama to Cape Horn* by Edith Salisbury. A market in Huancayo is pictured on page 51 of the Chamberlain book, and 468 of *Our Our World Today* by Stull and Hatch. There is an interesting article, "Springtime in the Highlands" by Elizabeth L. Ledig on page 30 of *Travel Magazine* for October, 1930. Pictures of the Concepcion and the Montaro valleys are shown among those of Huancayo.

On the way toward Lake Titicaca we came into Cuzco and the "land of the Incas." We found that the *Pan American Magazine* for August, 1931, gives a good picture of Cuzco, and another is given on page 104 of Frances Carpenter's book on South America. The town, located at the head of a broad valley 11,000 feet above the seas, is one-tenth as large as it formerly was. The central plaza is lined by women who sell everything from trinkets to household needs. Between sales they spin wool for the poncho and the rebosa.

Practically every textbook and every supplementary reader published mention Cuzco. They give considerable space to the endeavors of the Incas. These people having no written language were worshippers of the sun and the moon. A legend is told of how the Creator gave the first Inca, who came from the Island of the Sun in Lake Titicaca a rod which he was to drive into the earth. When and where in his travels he found a place where the rod went into the earth easily, he was to build his capitol. Since the earth did not resist the rod at Cuzco it was

declared the center of the kingdom. The land surrounding it was divided into provinces which in turn were distributed among shepherds and farmers who terraced the mountain sides and dug canals for irrigation.

The Incas who established both roads and rest houses were marvelous builders. There has been a question as to how the rocks were gotten from the quarries and put so close together without mortar that not even a knife blade could be placed between them. A part of the wall of one of the churches in Cuzco today as well as that of a convent was once a part of the beautifully carved Temple of the Sun.

On the advent of Pizarro many of the men fled from Cuzco carrying certain treasurers with them and throwing some into the Lake to save them from the Spanish. The leader of the Incas, Atahualpa, was called upon to fill with gold as high as he could reach a room almost fifteen feet square. In return for fulfilling the order, Atahualpa was killed at Cajamarca, one of the interior towns having little in common with the others except a Temple to the Sun indicating that the inhabitants were very possibly sun worshippers.

The pupils recognized the fact that they could go on at length talking about the Incas and the adjustments that they had made in the mountains. Attention was turned to life in Peru today. "The Place Where the Sun is Tied" by Richard Haliburton on page 16 of the September, 1929, issue of the *Ladies Home Journal* gives a fairly good picture of the area around Cuzco. The pupils read "Highlands of Peru Today" on page 85 of *Southern Lands*. They found that the *Pan American Bulletin* for August, 1932, page 353, contains an interesting map on marketing. *The Nation* for January, 1926, page 78 gives a picture of the new Peru, a united nation of 4,000,000 people. Members of the class decided that with only ten per cent of the population made up of whites that such a union would be difficult.

The trip from Cuzco to Mollendo was made on The Southern Railway through Puno on Lake Titicaca and Arequipa, the woollen market of the South. The story about Lake Titicaca beginning on page 308 of *South America* by Nellie Allen, and Chapter XIV of *South America* by Frances Carpenter were among the best available. Pictures of balsas are shown on page 131 of *South America Today* by Rufus Austin White, 48 of *South America* by the Chamberlains, 146 of *South America* by Isaiah Bowman, 220 of *The Western Hemisphere, Book II* by

Bramon and Ganey, 367 of *American Lands and People* by J. R. Smith, and page 114 of *South America* by Frances Carpenter.

Lake Titicaca on the boundary line between Peru and Bolivia is about a hundred sixty-five miles in length and thirty in width. The lake was at one time larger than it now is. There is no outlet to this body of water that is fed by a few icy mountain streams. Puno on the Peruvian and Iuaqui on the Bolivian side with towns by the same names are two of these. The body of the lake never freezes but ice forms near the shore practically every month of the year. People make no attempt at swimming in the water since they would perish from the cold. Certain plant life in the lake may have found its way there by means of underground streams. The islands of the Sun and of the Moon are supposed to have given the Inca ruler and his wife.

Balsas seen on Lake Titicaca 12,000 feet above the sea, are made from reeds that grow twice as tall as man. When these light boats become thoroughly water soaked they are torn apart and the reeds are used for huts. An up to date English ship unloaded at Mollendo was sent in parts to Puno. An article by L. S. Blaisdell in the *Pan American Bulletin*, page 835, describes this boat.

The objective for the last day of the study of Peru included getting acquainted with Arequipa. Here again references were short and widely scattered. A description beginning on page 333 of *South America* by Nellie Allen is good, as is the story beginning on page 109 of *South America Today* by Rufus Austin White. A good picture is given in the *Pan American Bulletin* on Peru. In carefully considering these, the material in the following paragraphs should be included.

At an elevation of 8,000 feet, Arequipa was founded by Pizarro in 1540. It is located on the deep gorge of the Colca a branch of the Rio de Najes. Arequipa, "The City Beautiful" is the home of more than fifty thousand people. Certain houses with their wide plazas are comportable. Many of them have walls from five to nine feet in thickness as a safeguard against earthquakes wherein many people have lost their lives. These houses are quite in contrast to the tinroofed huts of the mountain shepherds who barely exist on meat and frozen potatoes grown on the poorly equipped farms for which they seem to have an affection. Many of these homes are cold and miserably heated with the dung of the llama.

Throughout much of Peru the principal means of transport is by pack animals. Although frequently we fail to think of the mule as a beast of burden in Peru it is used also since it is the strongest of all. It will carry between two and three hundred pounds while the llama, the well known beast of burden, carries only from seventy-five to a hundred. This sure-footed beast is somewhat ill-mannered, being inclined to spit or to lie down if too heavily loaded. Pictures of the llama are shown on page 97 of *South America* by Gertrude Southworth, 103 of *South America* by Frances Carpenter, 263 of *South America* by Isaiah Bowman, 320 of *South America* by Nellie Allen, 54 of *Our Continental Neighbors*, by Brigham and McFarlane, 247 of *Living Geography, Book II* by Huntington, Benson, and McMurray, 367 of *American Lands and People* by J. Russell Smith, 203 of *North and South America* by Bodley and Thurston, and 326 of *Living in the Americas* by W. R. McConnell.

The alpaca, a rather fragile beast, is pictured on page 326 of *Living in the Americas* by W. R. McConnell, and 97 of *South America* by Gertrude Southworth, while the vicuna, a more fragile beast still, is pictured on page 146 of *South America* by Edith Salisbury and 125 of *South America* by Rufus Austin White. These beasts are supplemented or perhaps preceded by skilled runners—human carriers, who in certain instances covered more than a hundred miles a day when bringing fish and fruit for their ruler's breakfasts—continue as the chief means of transportation in the highlands of Peru today.

The modern section of Arequipa is a fairly up-to-date distributing center of the interior. It is the center of the trade in wool. A map in *Living in the Americas* by W. R. McConnell, page 320, shows the grazing lands. Wool is the largest item of freight carried on the Southern Railway. In addition to necessities, jewelry, and certain other luxuries are made in Arequipa. There are telephones, electric cars and lights. The shops for the Southern Railway that we traveled on from Cuzco are also located in Arequipa.

Before considering leaving Arequipa it was of interest to visit Mt. Misti, the site of the observatory established by Harvard University largely because of the rare atmosphere and the cloudless condition of the sky. The many clear days and especially starlit nights makes the observation of the heavens through a telescope having a lens two feet in diameter easy. There is a station house at the base as well as near the top of

the 20,000 foot peak. The mountain is pictured on page 203 of *North and South America* by Bodley and Thurston and on page 325 of *South America* by Nellie Allen.

The trip from Arequipa to Mollendo was found to be rather monotonous. The latter town is shown on page 331 of *South America* by Nellie Allen, 105 of *South American Lands* by Rufus Austin White, page 53 of *Our Continental Neighbors* by Brigham and McFarlane, page 201 of *North and South America* by Bodley and Thurston, and on page 242 of *Living Geography, Book II* by Huntington, Benson and McMurray.

Mollendo is the important port for the southern part of the country; in fact it serves not only Peru but also Bolivia. It is now affected by competition from the Arica-LaPaz Railroad. There is no particular need for loading docks at Mollendo since the water there is very shallow and not easily reached by ocean going vessels. Boats approaching are met some distance out by lighters that aid in discharging cargo. The pupils were interested in a picture showing a lady seated in a chair, luggage in her lap, being lowered from the large to a small boat fifteen feet below. The getting into the smaller boat by means of a ladder was also quite a feat. Generally there is someone on hand to guide and to keep the passenger from going into the sea. The pupils were interested in pictures showing cattle struggling suspended from a crane by means of a heavy belt around their bodies. They too were being lowered to a smaller boat to be taken to the shore.

The pupils now recognized that they had not only made a short trip into Peru by way of the oil fields and Paita to the north but that they had also made a circuit within the country doubling back on the return from Iquitos and Cerro de Pasco. After tracing the route on a large map placed on the bulletin board and marking the places of outstanding interest, Tumbez, Talara, Paita, Piura, Iquitos, Callao, Lima, Oroyo, Cerro de Pasco, Huanacayo, Cuzco, Arequipa, and Mollendo, with colored tacks, the pupils made the following list of relationship statements:

Coastal Plain

1. Importance of Tumbex and Talara	deposits of oil near enough to surface and to ocean outlet to pay for drilling
2. Location of Paita and Piura	Piura River supplies water for irrigating fairly fertile soil

3. Growth of Calloa	best harbor along the coast, outlet for crops grown in irrigated valley of Rimac that supplies water for irrigation
4. Importance of Lima	governmental market town along the Rimac that supplies water for irrigation
5. Location of Mollendo	best natural outlet for southern Peru
6. Growing of cotton, sugar cane, and vegetables	fertile soil near the coast where small streams supply water for irrigation.

Mountain Interior

7. Development of mining near Cerro de Pasco and Oroyo	mineral deposits in paying quantities
8. Grazing of cattle, sheep, llamas, alpacas, vicuna	scanty supply of grass on rugged lands of the interior
9. Raising of potatoes, barley, rye, and vegetables	scanty supply of poor soil, valley land, and high elevation
10. Location of Cuzco and Arequipa	centers of exchange in valleys and in high lands

Eastern Lowland

11. Location of Iquitos	along Amazon River
12. Exchange of tropical products	twelve month growing season, heavy rainfall

The testing exercise over the study of Peru consisted of matching the natural to the cultural sections of the relationship statements copied from the board into notebooks. The left hand column was left intact while the items in the right were cut apart, thoroughly jumbled and pinned where they belonged opposite the items in the left hand column. For example, if a pupil happened to pick "Piura River supplies water for irrigating, fairly fertile soil" he pinned it after No. 2 in the left hand column. After the work was completed and final checking was done, the pupils declared that they had enjoyed the study of Peru. Since this was true beyond a doubt, a greatly desired outcome had been reached. Not only had the pupils enjoyed the study but they had gained a sympathetic understanding of the Peruvians and their problems.

In our country and in our times, no man is worthy the honored name of statesman who does not include practical education of the people in all plans of administration.—HORACE MANN.

RATIO AND PROPORTION IN HIGH SCHOOL CURRICULUMS[1]

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Everyone uses measurable quantities,—such as time, money, length, area, and volume. He also needs to understand the relationships of these quantities when he is dealing with such commonplace matters as making a budget, buying canned foods, or reading a newspaper article illustrated by graphs.

The high school pupil meets these ideas of relationship in many places,—especially in chemistry, physics, and mathematics. In the latter subject the study of ratio, proportion, and variation furnishes an ideal means of grasping the "function concept." But one may well ask whether the pupil understands what he is studying.

In 1932 the author found from a questionnaire answered by three thousand pupils studying geometry in the public high schools of a large city that the majority of these pupils had poor conceptions of the words "ratio" and "proportion."[2]

The purpose of the present paper is to study the high school pupils' grasp of relationship of measurable quantities, as revealed by the comprehension of ratio and proportion.

This paper consists of five parts:—I. An examination of textbooks in high school mathematics to ascertain whether the treatment given to ratio and proportion brings out the idea of relationship. II. A similar study of textbooks in other subjects,—especially chemistry and physics. III. An analysis of some published articles written by teachers of chemistry and physics regarding the amount and character of mathematics required by high school pupils studying these subjects. IV. Results obtained from a questionnaire sent to pupils studying chemistry or physics in the public high schools of a large city. V. Conclusion.

Part I. An Examination of Textbooks in High School Mathematics

The books studied include ten texts in plane geometry (published in 1911, 1912, 1924, 1925, 1925, 1926, 1927, 1928, 1931,

[1] This paper was accepted by the International Congress of Mathematicians held in Oslo, Norway, July 13–18, 1936. A summary will be found in the proceedings.

[2] E. B. Cowley, "Technical Vocabularies for Plane and Solid Geometry" presented to the International Congress of Mathematicians, held in Zurich, Switzerland, September 4–12, 1932 A summary is given in *Mathematiker-Kongress, Zurich, II Band, Sektions Vortrage*, pp. 209–210. The entire paper is reproduced in the *Journal of Educational Research*, XVII (January, 1934), pp. 344–354.

and 1932); one text in general mathematics (1923); and four texts in algebra (1924, 1925, 1936, and 1936). These books will be referred to by the numbers 1 to 15 respectively.

The method of writing a proportion may, at first glance, seem to be a trivial and insignificant matter; but thoughtful attention soon leads to the conclusion that the symbolism is of real importance. If a proportion is written as a fractional equation, it is at once tied up in the pupil's mind with fractions. He knows that the numerator and denominator are related and that a change in either alters the value of the fraction, but that certain changes made in both leave the value of the fraction unaltered. If the proportion is written $a:b::c:d$ and is read "a is to b as c is to d," the pupil may see no connection with anything he already knows.

The depths of obscurity are reached when the pupil is required to learn "theorems" about "antecedents," "consequents," "means," "extremes," "alternation," "inversion," etc. But if a proportion is written as a fractional equation, the pupil can readily see how the use of axioms will enable him to obtain the necessary transformations. Nevertheless, texts 10, 11, 12, and 15 are the only ones of the fifteen that are free from these "theorems." The number of such "theorems" in the eleven other texts varies from one (text 14) to fourteen (text 13).

This obsolete, mechanical presentation of ratio and proportion is employed in spite of the fact that the report of the National Committee on the Reorganization of Mathematics in Secondary Schools (1923) urged that the idea of relationship be made dominant in high school work.

Part II. A Study of Textbooks in Other Subjects

In chemistry an examination was made of ten texts (copyrighted in 1920, 1922, 1925, 1925, 1927, 1928, 1930, 1931, 1931, and 1936). The question of whether the author of a chemistry textbook brings out or ignores the concept of relationship in his treatment of proportion can be answered by studying his methods (1) of expressing certain laws, and (2) of solving certain types of chemical equations.

The Law of Charles (or Boyle) may be expressed either by the words directly (or inversely) proportional, or by the phrase varies directly (or inversely). The author of text 3 expresses the Law of Charles in terms of "directly proportional," and adds

the fractional form $V_1/V_2 = T_1/T_2$. Likewise, after Boyle's Law $P_1/P_2 = V_2/V_1$. He also uses the word "proportional" in stating such laws as Faraday's, Henry's, and that of molecular concentration. All this is in striking contrast to the lack of emphasis upon relationship which characterizes this author's treatment of chemical equations.

Let us consider the problem of finding the weight (say of oxygen) from a given weight (say of potassium chlorate); or the reverse problem. In texts 1, 3, 5, 8, and 9 the proportion is written in one or both of the forms $a:b::c:x$ and $a:b=c:x$. Texts 1 and 9 give the numerical value of x at once, without any explanation. In text 8 the author obtains a rough estimate of the value of x, and then advises the pupil to get exact results by the use of proportion,—which is described as a "device" from arithmetic. The pupil is told that if he succeeds in placing the four quantities in correct order, the product of the end quantities will equal the product of the middle quantities. In these five texts the idea of relationship of quantities is ignored in solving chemical equations. Textbook 10 is a practical, descriptive course for one semester. The pupil solves no equations and uses neither ratio nor proportion.

Each of the five other textbooks gives a more adequate treatment of the solution of chemical equations. The author of text 2 does not write proportion in any of the three forms already mentioned, but says (in effect) that if "a" grams of potassium chlorate yield "b" grams of oxygen, then one gram of potassium chlorate gives b/a grams of oxygen, and ten grams of potassium chlorate will give ten times as much oxygen. In texts 4, 6, and 7 a proportion is written as a fractional equation, and in no other way. The author of text 4 asks the pupil to state the "proportion, or equation," and then to solve the equation to find x. This author calls attention to the usefulness of the idea of relationship in these problems of weights.

In physics five textbooks (copyrighted in 1912, 1922, 1922, 1934, and 1936) were examined. Since this subject is closely related to chemistry, and overlaps it in many places, the study of these five texts yields results similar to those obtained from the ten chemistry books. The term "ratio" is used frequently in physics,—as in the definitions of the "mechanical advantage" of a machine, and of the "relative humidity" of the air. Newton's law of cooling brings in the term "rate." In problems involving the amount of light a body receives from a luminous

object, there are similar polygons, with their proportional sides. The author of text 4 advises the pupil to divide "cubic" feet by feet to get "square" feet, adding that the procedure would not be approved in "formal" mathematics, but assuring the pupil that it does help the beginner! Although text 5 is a practical, descriptive course of one semester and avoids problems, the terms ratio and proportion are used correctly.

Music is another subject in which the concept of relationship plays a part. The laws of intensity of sound, of harmonious sounds, and of vibrating strings are expressed in physics by means of ratios and proportions. These laws are fundamental in the study of music. Examine a textbook in harmony, and you will see why a person who has little or no idea of the relationships of quantities is bewildered when he tries to understand such terms as octave, or perfect fifth, or tone combination, or the statement that the relation of one tone to another is purely a matter of mathematical ratio.

Art needs ratios and proportions. This subject takes from physics the laws of illumination, and from geometry the similarity of figures and the space relations of lines and surfaces. In the Course of Study in Art for the public schools of one large city (1931), "proportion" is listed as one of the five major principles of arrangement. Elsewhere in this course proportion is spoken of as the appreciation of fineness of relations which should govern composition.

In the drafting room ratios and proportions are constantly in use in scale drawing. In biology Mendel's Law is expressed by the use of the word ratio.

In cooking the idea of relationship is needed by everyone who has occasion to take a recipe given for six servings and adjust it for two, three, or more servings. The recipes for different kinds of white sauce show variations in the relative amounts of certain ingredients.

In sewing, a person is a slave to a pattern unless she knows how to alter and modify, while preserving certain proportions. One textbook gives the directions for drafting patterns by the use of equations written out in words and illustrated by geometric figures. These figures are, of course, similar to the patterns to be drafted.

In shop and industrial training there is need of the laws of electricity and the laws of machines, which are given by means of relationships expressed by ratios and proportions.

The "social sciences," too, are dependent upon the ideas of relationship:—the various relations of supply and demand; of crops to soils, fertilizers, and insect pests; of water supply to health; and hosts of other relations which will suggest themselves to the reader's mind.

Finally, it seems fair to claim that almost every subject in a high school curriculum uses the idea of relationship which is expressible by means of mathematical ratio and proportion.

PART III. AN ANALYSIS OF ARTICLES BY TEACHERS OF CHEMISTRY AND PHYSICS

For more than three decades teachers of chemistry and physics have been publishing articles upon the knowledge of mathematics possessed, or needed, by high school pupils studying these subjects. An appendix to the *Proceedings of the Second Annual Meeting of the Central Association of Teachers of Science and Mathematics* (1903) contains a report of the committee on the Correlation of Mathematics and Physics in Secondary Schools. This report contains long discussions of ratio, proportion, and variation. Many articles have since appeared in SCHOOL SCIENCE AND MATHEMATICS, the journal of that association. A few of these articles which bear directly upon the questions discussed in the present paper will now be briefly reviewed.

In "The Mathematics of Elementary Physics" (Volume 20), the question of whether this subject is too mathematical is faced squarely. The answer is "no." The author is certainly speaking to the point when he says that too often the teaching of algebra consists merely of perfunctory drills, without thought or application.

"The Mathematics Needed in Freshman Chemistry" (Volume 21) applies equally well to high school classes. The author analyzes the textbook used in his own classes. Under frequencies of "mathematical concepts" he gives "per cent" as 310 times, ratio as 30, and proportion (and related terms) as 72. He says that there are only six fractional equations, and adds that these might have been considered as cases of "compound proportion"! He writes a chemical equation with four colons, adding that there are 59 such cases. He assures us that no algebra is needed for the solution of proportions. He says that there is little need for mathematics; and then immediately demands a good working knowledge of arithmetic and parts of algebra and geometry.

—specifying percentage, ratio and proportion, fractional equations, measurements of surfaces, volumes, etc. Finally, this man who has displayed his ignorance of mathematics, has the audacity to suggest that chemists prepare sets of questions and distribute them to high school teachers of mathematics to use instead of the material ordinarily given in algebra, geometry, and trigonometry classes!

In an article on "The Mathematics Involved in Solving High School Physics Problems" (Volume 25), the author thinks that the pupils' difficulties are due chiefly to the poor work done in the traditional course in algebra, where too little attention is given in the first year to the solution of formulas and where ratio, proportion, and variation are put off to the third semester's work. The pupil is apt to omit this algebra, or to take it after he has had physics.

A teacher in a technical high school writes very clearly on "Some Simple Uses of Mathematics to Clarify Chemistry" (Volume 29). He develops a chemical equation, writing the proportion as a fractional equation. He also explains variation. In striking contrast is an article on "The Mathematics Used in Solving Problems in High School Chemistry" (Volume 30). Three of the ten textbooks in Part II of our paper are discussed. The lists of "mathematical" terms include such words as atmosphere, atomic weight, calories, molecule, and mole. The author states that (1) one of the three textbooks (#7 of our Part II) avoids the use of proportion entirely in solving chemical equations; (2) that proportion is not essential in chemistry; and (3) that many pupils are unfamiliar with proportion, because it is optional in many courses in arithmetic. The truth of the matter is that in the textbook in question proportions are written as fractional equations. What chance have pupils whose teacher cannot recognize a proportion when it is written as a fractional equation?

These questions are still with us. In the issue of June, 1936 (Volume 36) there is a "Discussion of Mathematical Tests Given to Science Pupils." The author says that 94% of the members of the association answered "no" to the question as to whether mathematics should be largely eliminated from high school physics. However, teachers of physics spend, on an average, twelve hours per year in teaching arithmetic. It would be profitable to try to find out what they teach and how and why they do it.

PART IV. RESULTS OBTAINED FROM A QUESTIONNAIRE

The questionnaire which is given below was answered by almost two thousand pupils who were studying chemistry or physics in the public high schools of a large city. (In 1932 a questionnaire was sent to the pupils studying plane geometry or solid geometry in these same schools.) The questionnaire follows.

Part I. In the following list (1) check the subjects which you are now studying; (2) cross out the subjects which you have never studied: Chemistry 1, Chemistry 2, Physics 1, Physics 2, Algebra 1, Algebra 2, Algebra 3, Algebra 4, Plane Geometry 1, Plane Geometry 2, Solid Geometry, Trigonometry.

Part II. The following questions are to be answered without help from any book or person. Explain in your own words the questions which you understand, giving a reason for each answer. Write your answers on this sheet.

1. In a retail store if one grade of muslin is sold at ten cents a yard, are the prices paid by two customers proportional to the number of yards of this muslin which they buy?
2. Is the ratio of 45 feet to 60 feet equal to 105 feet, or 15 feet, or 3/4, or 2700?
3. If $20.1/79.9 = 8/x$, how do you find x? To what number is x equal?
4. What percentage of 122.5 cubic feet is 39 cubic feet?
5. Are the weights of boys always proportional to their ages?
6. If a side of one square is twice the side of another square, is the ratio of their areas equal to 2, or 4, or 8, or 16?
7. If the radius of one circle is three times the radius of another circle, what is the ratio of their diameters? What is the ratio of their circumferences? What is the ratio of their areas?
8. If water is flowing into a tank at a uniform rate, does the amount of water that has flowed into the tank vary directly or inversely as the length of time that the water has been flowing?
9. In $\triangle ABC$ and XYZ, the $\angle A$ and X are right angles and $\angle B = \angle Y$. If $BC = 6$ inches and $CA = 3$ inches, to what number is YZ/ZX equal? If $YZ = 17$ inches, how many inches in ZX?
10. Is the number of teaspoonfuls of baking powder used in making biscuits proportional to the number of cups of flour used?

In the city in which these questionnaires were answered, the senior high schools offer four curriculums:—general, college preparatory, commercial, and practical arts. It was impossible to get any reliable statistics on the number of pupils in the various curriculums because (1) the number of electives is so much greater than the number of required subjects that it is possible for a pupil to fulfill the requirements of more than one curriculum, (2) pupils often change from one curriculum to another, and (3) administrative officers sometimes waive requirements.

The college preparatory course requires one year of algebra (Algebra 1 and Algebra 2) and one year of plane geometry (Plane Geometry 1 and Plane Geometry 2). Each of the three other curriculums requires but one year of mathematics beyond the eighth grade, and that may be either algebra or commercial arithmetic. For courses in chemistry and physics there are no prerequisites in mathematics.

From the responses to Part I of the questionnaire a study was made of the mathematical preparation of the pupils. As the test was given four weeks before the end of a semester of twenty weeks, no distinction was made between mathematics courses that were then being taken and those that had been completed. For convenience the term "normal" has been used to indicate the mathematical preparation which consisted of Algebra 1, Algebra 2, Plane Geometry 1, and Plane Geometry 2 (i.e., a year of each subject). Approximately two pupils out of five had normal preparation, one out of five was below normal, and two out of five had one or more semesters' work in addition to the normal preparation. See Table I for the percentages.

The high schools differed greatly in the mathematical preparation of their pupils who were studying chemistry and physics. At one extreme were the classes in Chemistry 1 (the first semester of chemistry) where from 50% to 55% of the pupils were below "normal." At the other extreme were those classes in Physics 2 where every pupil had at least normal preparation. Not all classes in Chemistry 1 were so poorly prepared, for one class had only 5% of its members below normal. Nor were all Physics 2 classes so well prepared, for one class had 25% of its members below normal.

The number of pupils studying chemistry was approximately twice the number studying physics. See Table II for percentages. (The number taking both subjects was negligible. Such a pupil was listed under the subject in which he was taking the second semester's work, as no one was taking the second semester in both subjects.)

In Part II the pupils were requested to give reasons for the answers. The information furnished by these reasons was not of a nature to be rated in percentages. Hence, in computing the percentages of correct answers full credit was given even when the pupil had not written a reason. The only questions that were answered correctly by at least 70% of the pupils were numbers 1, 2, 5, and 10. Questions 6, 8, and 9 were answered cor-

rectly by approximately half the pupils. Only 40% of the pupils solved correctly the linear equation in one variable (number 3), although 97% of the pupils had had at least one year of algebra. The lowest scores (20%) were made on questions 4 and 7. In the percentage problem (number 4), the answers varied from .0032% to 31800%. In number 7 no credit was given unless the three ratios were correct. Many of the pupils gave the third ratio as 3 instead of 9. This is a common error. It is sometimes found even in pictorial representations published by statisticians. Geometry teachers need to look out for it. Table III gives the percentages of correct answers for the ten questions.

The most frequent reason for a negative answer to question 1, 5, or 10 was "because the product of the means is not equal to the product of the extremes." The textbooks in plane geometry, chemistry, and physics used in those high schools do not employ the terms "means" and "extremes"; but all the textbooks used in algebra do employ these terms. One of the algebra textbooks (copyright in 1901) gives fifteen "principles" concerning ratio and proportion, and employs such terms as antecedent, couplet, ratio of greater inequality, composition, and triplicate ratio. Of course, an alert and up-to-date teacher can do as much to counteract the bad influence of a poor textbook as an antiquated teacher can do to ruin the good effects of an excellent textbook.

Negative answers to the first question were explained in other ways, as "If you bought a lot, you could get it for next to nothing," and "3 yards would be $.29 in any store run by a smart merchant." In answering the fifth question some pupils added, "Some boys are underweight." The reasons assigned varied from internal troubles, such as "glands," to external difficulties, such as parents and schools. The explanations given for negative answers to the tenth question were surprising—"because baking powder is very strong," "they would not be fit to eat." "they would run all over the stove," and "there would be too much carbon monoxide, and that kills you."

TABLE I

	below "normal"	"normal"	above "normal"
Chemistry pupils	26%	45%	29%
Physics pupils	11%	30%	59%
Both	21%	40%	39%

TABLE II

Chemistry classes had 68% of the pupils; and physics classes had 32%.

TABLE III (Percentages of correct answers)

(1) 85%	(2) 75%	(3) 39%	(4) 20%	(5) 80%
(6) 48%	(7) 21%	(8) 51%	(9) 49%	(10) 70%

PART V. CONCLUSIONS

1. The concept of relationship is slowly but surely becoming the dominant idea in the treatment of ratio and proportion in textbooks in mathematics, chemistry, and physics. There are a few conspicuous exceptions.

2. Published articles written by teachers of chemistry and physics indicate that these teachers differ widely in their use of relationship in proportion.

3. Questionnaires answered by pupils studying chemistry or physics show (1) that from 70% to 85% of the pupils have a sufficient grasp of the idea of relationship to answer easy questions expressed in terms of everyday affairs, and (2) that some of the pupils have difficulties with the problems because they look at proportion as merely a mechanical device worked by arbitrary "rules."

4. The importance of the idea of relationship inherent in ratio and proportion must be emphatically presented to teachers, writers of textbooks, supervisors, administrators, educational diagnosticians, and curriculum builders.

SKELETON

With a spear still sticking in his skull, the skeleton of a prehistoric fighter has been unearthed in the bank of the River Irtysh, western Siberia.

The ancient Asiatic, found with his bow and a stone slab still clutched in his hand, is being studied at the Semipalatinsk Museum. His frame is pronounced that of an unusually big man, with a large and protruding lower jaw, arms so long they hang below his knees, and wrist and feet half as big again as those of an ordinary modern man. His skull was flattened at the back.

The Asiatic war, or feud, thus revealed was in an era when bone, rather than steel, provided weapons, judging by eight bone arrows and the spearhead at the scene. Earrings of ornamental burnt clay were found nearby.

FERTILIZER

Germany's self-imposed iron necessity for self-sufficiency has resulted in the discovery that low-grade German copper ores can be used as fertilizer in the place of copper sulphate, which must be imported, U. S. Consul Sidney R. Eedecker here reports.

Use of milled copper-bearing rock is claimed to be even superior to the imported relatively pure mineral. Copper deficiency of soils in northwestern Germany posed the problem.

THE FUTURE OF THE SPECIAL SCIENCES IN THE SENIOR HIGH SCHOOL*

By Ralph K. Watkins
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Courses in the curricula of high schools of the present day move in the direction of the generalized course which draws its content from the several older more specialized subjects, and from the inter-relationships of these subjects with the fabric of life itself. English has already travelled this road. The social sciences have almost completed a similar type of pattern. At the junior high school level, both science and mathematics have each been organized into general courses. In the senior high school the special sciences of chemistry and physics, and the special mathematics courses, tend to hold their own. In the current of present trends what is to be the future of these remaining subjects?

Since the reports of the Commission on the Re-organization of Secondary Education beginning in 1915, ninth grade physical geography has practically disappeared. Botany and zoology exist only here and there in the very large high schools. Percentages of enrollments of pupils in high school chemistry have stood still these 40 or 50 years. In the very last report of the North Central Association there is shown a slight increase for chemistry in this territory. Percentages of enrollment of pupils in high school physics have been slowly falling off over this same period. This slow decline continues.

General science has grown in twenty years from nothing to a position as the dominant high school science. It has reached a place where 16 to 18% of high school pupils are enrolled in it and has remained at that point now for several years. The most remarkable growth in science enrollments in recent years has been in general biology, which bids fair to catch up with general science in popularity, if it does not ultimately surpass it. The high school science that seems to be particularly in the doldrums is the one of special interest to this group of science teachers, physics.

Obviously the successful sciences from the point of view of

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enrollment and apparent interest of the pupils are the generalized sciences.

In the early stages of the process of generalization of science courses the college teacher looked upon the development with the skeptic's sneer.

Now we have the generalized science courses at the college level, especially in the junior college years. The survey course of the University of Chicago published as *The Nature of the World and Man* is familiar to all. The published text even became a best seller and reached the dollar edition class. The survey courses of the General College of the University of Minnesota are also familiar. Other colleges, especially junior colleges, are offering either survey or general terminal courses in science.

This junior college movement, in many ways identical with the earlier junior high school movement, leaves the teachers of high school physics and chemistry in a particularly unstable position, a sort of island upon which may project the only special sciences taught from grades seven to fourteen. If the generalized sciences of the lower grades continue, and the tendency towards survey and generalized terminal courses at the junior college level further develops, the position of the special sciences in the senior high school becomes largely indefensible.

In terms of the essential logic of the situation three things may happen.

(1) We may develop a real program of science instruction in the elementary school and the junior high school which can complete the science training needed in a general program of education. This will clear the field at the senior high school and junior college levels. In this case the special sciences may be continued and further developed in the senior high school and the junior college. This program would seem to imply the abandonment of the generalized courses of the junior college, and a return to the special sciences, but to a sequence of courses in the special sciences built upon and integrated with the beginning special science courses of the senior high school. This suggested co-ordination and integration of senior high school and junior college courses in the sciences has almost never been successfully accomplished to date.

(2) We may generalize the science courses of the senior high school, leaving the beginning of training in the special sciences to the colleges, either at the junior or senior college level. In

effect this would mean moving courses similar to the survey and generalized terminal courses of the junior college down into the senior high school, and the abandoning of present courses in physics, chemistry, and other special sciences in the high school.

(3) We may generalize the material of the physical sciences into one course in general physical science as we have done with the biological sciences in the present course in general biology. Such a course would include not only materials from the fields of physics and chemistry, but also content from geology and astronomy, and possibly from other sciences.

In carrying out this latter program, small high schools would probably abandon the present courses in physics and chemistry. Larger schools might possibly do the same, or follow the two general courses in biology and physical science with training in selected special sciences. The general courses of the senior high school may be organized to fit into a widening and expanding program of further generalized science courses in the junior college, or may be used to terminate the training of a general program and be followed by beginning special sciences in the college.

This third option seems at present to be the line of least resistance. There are evident stirrings on the part of a number of high schools which indicate a keen interest in the development of a course in general physical science in the senior high school to follow the present course in general biology. Teachers of high school physics and chemistry may find themselves teaching general physical science as best they can in the not too remote future.

It may be well to pause in the midst of outlining possible predictions of the future of the special sciences as school subjects and make some inquiry concerning the apparent lack of popularity of courses in special sciences in the high school. In the midst of our present enormous uses of the sciences, why is there an apparent lack of concern with the sciences on the part of many high school pupils?

In examining this situation we must try to get a fair picture of the conditions. There are actually more pupils in training in the high school physics and chemistry classes today than there ever have been in this country before. This is probably not true for high school physical geography, botany, or zoology, but is true for physics and chemistry. The problem is not for the moment in the total numbers in the sciences, but in the ratios

of the pupils in the various special sciences to the total number of pupils enrolled in high schools.

In many high schools there is offered an increasingly wider variety of courses in many subjects on an elective basis. This diversity of opportunity for the pupils tends to reduce the percentages of enrollment in the older long established courses. Twenty-five years ago the course in physics in the eleventh or twelfth grade did not compete with such a wide range of other subjects also offered in the eleventh and twelfth grades. Interest in, and opportunity to receive training in, music, art, speech, dramatics, journalism, industrial arts, and a considerable variety of vocational subjects tend to draw some students away from physics and chemistry, as well as from upper year mathematics and the languages.

Early opportunity for some acquaintance with science training and content in junior high school science, general science, and general biology, may satisfy some pupils who do not have very intense science interests, so that these pupils do not elect special science courses in later years.

All of these factors exist and undoubtedly must be considered in a rational explanation of our situation. These are but dodges in facing the issue, however. Why is there an apparent lack of interest in the special sciences on the part of many pupils? In some high schools, pupils deliberately avoid the courses in physics and chemistry.

An offhand answer is that these subjects are difficult and that the modern high school youth has gone soft, and so avoids the subjects with reputations for difficulty. This is consoling rationalization for the physics teacher, but may not be true. Given a vision of the possibilities within an area of training, high school pupils are often willing to do much hard work with a difficult content.

A pertinent suggestion is that the difficulties of physics and chemistry are not in the ideas, concepts, and methods of the sciences themselves, but in unnecessarily technical vocabularies (for high school pupils), in the details of technical and industrial processes that may not contribute to understandings of the concepts in the sciences as such, and in the rather far-fetched mathematical problems that often contribute relatively little to essential understandings.

The special sciences have been taught to the rank and file of high school pupils as if they were all to become physicists or

chemists. If we could only convince the science teachers that the great majority of pupils in high school and beginning college courses in the sciences are never going to become scientists, we might approach a renaissance in our science teaching. As schools are now organized, the teachers of the remaining special sciences in the high schools must very soon realize the need for a consumers' science if their courses are to survive.

The special sciences have not been taught in such a way that they aid young people in interpreting the world in which they live, but rather as disciplines, or as systems of knowledge, which the school authorities have considered as worth imparting to the coming generation. This is probably the fundamental difficulty with the teaching of the special sciences and accounts for the disappearance of part of them from the high school program.

The generalized sciences as they have been taught in high school and junior high school have had two advantages. (1) There has been an attempt in the organization of these courses to help the young people coming into them to better understand the world in which they live. (2) The artificial separation of related scientific phenomena and applications is avoided.

With reference to the first point, there is no claim that current organizations of generalized science courses are entirely successful in accomplishing the purposes for which they are set up. There is no very satisfactory solution to the problem presented by the enormously great array of materials from which the content of such courses must be chosen and organized. On the other hand these courses have moved in the direction of meeting the needs of the youthful layman for science.

On the second point, the separation of the special sciences is condemned by the advances within the sciences themselves. When matter becomes a manifestation of energy, and electrical energy is the essential essence of matter, what becomes of distinctions between physics and chemistry. General biology offers the best opportunity for dealing with the essential oneness of all living matter. No course in one of the biological sciences has quite the unique opportunity for teaching the essential needs of all life that the general course has. When this problem is considered in biology, how is some chemistry to be avoided? As has been often pointed out, the problems of our daily living are not separated into physics, chemistry, botany, zoology, and geology. The trained scientist in an industrial situation is often confronted with a complex of sciences. For example, consider rubber.

Suppose for the moment we abandon this possible conflict of interests between those concerned with the special sciences and those concerned with generalized courses, and return to the common problem. Is there lack of interest in, and concern with, the whole area of the natural sciences on the part of modern youth? The best apparent answer to this is no.

There is time here to develop only one line of evidence. For this let us look to the out-of-school situation. There is such a demand on the part of young folk and their elders for science that there has developed a whole host of out-of-school agencies for satisfying the demand.

Newsstands carry a considerable number of periodicals devoted to popular and applied science of all kinds. Nearly every daily newspaper carries science news or popularization of research. There are even popular columnists in the science field. Books on science for the layman frequently get into the best seller class. Such things as simplified identification keys are now available in ten cent editions in the chain stores. Inexpensive, sometimes crude, tools and instruments of science such as microscopes, telescopes, barometers, and the like are currently sold in department stores. There is a definite and wide demand on the part of very many people for science if it can be made to more directly meet their needs. The future of all the science courses in the high schools is very specifically associated with what James Harvey Robinson has called "the humanizing of knowledge." Especially is the continued development of special science courses in secondary schools tied with the efforts of forward looking teachers to humanize the sciences.

So far in this paper we have allowed ourselves to be concerned with the survival and growth in our secondary schools of science courses of one kind or another, rather than with the growth and development of the human beings to be trained in such courses. After all what are we trying to do with our young people with our science organizations in the schools?

Science training in our present schools, and in those of the immediate future, can contribute materially to three types of education. These are: first, that type which we commonly speak of as general education; second, preparation for professional and high level specialized education, such as medicine, engineering, science teaching, agriculture, and the various types of science specialization; third, a type of education intended for workers in various service and occupational pursuits below the

professional level, such as the farmer, mechanic, electrician, gardener, plumber, or steam fitter.

From present trends, it seems probable that the contributions of the sciences to general education will be made available for the training of all young people through generalized courses. The reasons for this have been developed earlier in this paper. We do not yet know whether or not this general education is to be terminated at the end of the junior high school, the senior high school, the junior college, or at some other point. If the general education is to be completed early, some special sciences will be retained in the larger secondary schools to serve other purposes. If general education is to be continued through the senior high school, it seems probable that the offering of special science courses in the junior and senior high schools will cease.

If we continue to make some differentiation of training possible in the senior high school and the junior college, we shall continue the special sciences for the preliminary training of our potential professional groups who will need them as tools. Here is the particular field of our present special sciences such as physics, chemistry, botany, zoology, and geology. The individuals in this group need much more and better training in the various special sciences than we have yet attained at the secondary school level.

This leaves for the third type of training indicated a group of needed courses in applied sciences not yet well worked out. For the groups of people to be trained here, the present courses such as the existing high school physics and chemistry seem ill adapted. There are at present in some trade and technical schools the beginnings of courses of the kind suggested. There are a few textbooks available. Such courses as agricultural botany, an electrician's physics, household chemistry, and so on, are possibilities. The training in these courses needs to be very well done, but from the point of view of the potential worker, and at the level upon which he expects to practice. There is a crying need for this kind of training in our present world. It is doubtful if the courses of the kind offered in existing general or comprehensive high schools can be made to serve this need. It may be that this type of training will be carried over into the junior college in the near future.

If we awake to the educational problems of our present situation, we shall offer some similar science training to all our secondary school pupils, rich man, poor man, beggar man, thief,

merchant, doctor, lawyer, chief. We shall offer, beyond this, beginning training in selected special sciences of a thorough and tool type to those passing through the colleges, professional, and graduate schools into the professions utilizing scientific training. This is the field for the special sciences as we know them in the secondary schools. We shall develop service courses in applied sciences for those whose work calls for science training below the professional level, and who are now thrown upon the industrial world with no adequate training. This latter training would also presuppose a previous general training in science of the kind intended to meet the needs of all kinds of people for general integrating education.

None of these things may come to pass. The prediction of the future economic and social developments is beyond the occult powers of a seventh son of a seventh son, much less those of an humble observer of the current scene. The things outlined here seem to be before us if there is any logic at all in the educational and social trends that envelop us today.

TEACHING PHOTOGRAPHY IN HIGH SCHOOL

By Dean Challis

Dearborn High School, Dearborn, Michigan

During the past year we have been offering at Dearborn High School a one semester course in photography. Previously a course was given which included, among other topics, a study of photography but at present the course is entirely photographic. Most of the pupils taking the course are seniors. Two classes of about fifteen pupils each are conducted every semester.

Certain requirements were found necessary. Each pupil must have a camera with time exposure mechanism, an income of forty cents a week to be used for photographic supplies, and a real interest in photography. For the sake of economy pupils must use cameras which take pictures not larger than $2\frac{1}{2}\times4\frac{1}{4}$ inches nor smaller than $1\frac{1}{2}\times2\frac{1}{2}$ inches unless they have justifiable reasons for larger or smaller cameras. Roll film has been found best and most economical for the pupils' use.

The assignments are made on a weekly basis. Certain pictures are to be taken, developed, printed, sometimes enlarged and mounted, by a specified date. The pictures are taken out-

side of school hours and are the only outside assignments made. The developing, printing, and enlarging are done during class time using the school equipment. Two or three class periods of the week are used for this work and on the other days photographic processes are discussed.

The school equipment includes a darkroom which is used mostly for film development. This process must be done in the darkroom under very dim red light which is not enough for printing processes. The room is 8×11 feet and is equipped with running water, workshelves, red light for developing, orange light for enlarging or printing, individual lockers for chemicals, and an inexpensive electric clock with a second hand. The lockers mentioned were made by the instructor and are large enough to contain three quart bottles of solutions. Three sizes of glass developing trays are used for 8×10, 5×7, or print size work. A graduated measuring glass and a bottle of acetic acid complete the darkroom equipment.

Since enlarging and printing do not require absolute exclusion of white light such work is usually done in the main class room. This room has black shades at each window. Four orange lights illuminate the room for enlarging or printing. The usual physics laboratory tables are used as the worktables for trays, print boxes, and enlargers.

Print boxes are used and thus no white light escapes into the rest of the room where it would interfere with other persons' materials. The boxes were made at a cost of approximately two dollars each. Automask print frames were used for the top parts, but the covers were hinged. Six print boxes have proved quite adequate although eight would be more satisfactory. The automask arrangement makes it easy to change from one size of picture to another.

Four enlargers are now used: an Eastman autofocus model "A" which has been converted into a "B," a model "B," an Eastman Amateur Enlarger, and an Eastman Miniature Enlarger which will enlarge to ten diameters. The third mentioned, although only a sixteen dollar model requiring manual focusing, has proved very popular because it will enlarge as much as five diameters.

In order to give pupils the most practice at the least cost 5×7 inch enlarging paper is used most. The cost is approximately two cents per sheet, whereas the 8×10 inch paper costs about five cents per sheet. Pupils are shown how to make test strips

to avoid spoiling a whole sheet because of wrong judgment of time.

The same developer D-72 is used for all work. This saves expense and space and gives good results. Chemicals for the developer and fixer are weighed and dissolved by the pupils at least twice at the beginning of the course so that they will discover how it is done. After learning the process the pupils use prepared powders which make quart amounts.

All materials used, such as films, papers, chemicals, and accessories are bought from the school at reduced prices. In this way the school neither loses nor gains by the pupils' use of materials. Pupils doing extra or wasteful work penalize no one else.

Certain types of pictures are explained and assigned. Silhouettes, portraits, groups, architectural, candid, trick, sport, inside, night, and scenic pictures are included, as well as many others. A variety of types of work is essential to keep interest high. Intensive work in any one branch is left to pupil initiative. In winter months much work is done with photoflood bulbs. Reflectors are of cardboard and tables are used for tripods.

The meaning of "f" numbers, depth of focus, function of each chemical in developer and fixer, and exposure problems are discussed extensively. Less time is spent on discussion of lighting and composition.

During class time motion picture photography, projection, and processing are explained. Technicolor, kodachrome, chromatone, and dufaycolor processes are discussed as samples of color photography. Animated photography and sound films are explained. Various types of cameras are demonstrated.

No textbook is used in the teaching of the course. *How to Make Good Pictures* and *Elementary Photography* are frequently referred to, however, and a few copies are in the classroom. Magazines and newspapers have photographic articles of worth which trace the newer developments. The new book by Mees, *Photography*, has been a valuable aid.

Although the writer has taught all of the usual high school science subjects he has found photography to be the most interesting for both teacher and pupils. As a hobby or profession it has value ranking above the more traditional subjects. Experience has shown it to be a difficult but enjoyable course to teach. Why should not more high schools offer photography as a part of their curriculum?

THE CHEMIST AND THE CHEMICAL ENGINEER

By Saverio Zuffanti

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"Shall I become a chemist or a chemical engineer?" "What is the relationship between the chemist and the chemical engineer?" "How many types of jobs will be available to me if I become either a chemist or a chemical engineer?" These and many other similar questions confront the high school student who is seriously considering these two branches of endeavor. Many high school teachers are called upon to answer these questions each year. The following discussion, although it is not exhaustive in nature, will, I believe, aid considerably in clearing up this matter.

In discussing the fields of chemistry and chemical engineering one must first inform himself regarding the nature and scope of each and the relationship that exists between them. Each offers numerous opportunities in many industries to the adequately trained young man. Let us first consider the field of chemistry.

Chemistry

Chemistry may be defined as that branch of science which deals with the composition, structure, and transformations of matter. The chemist is, therefore, concerned with all of the different kinds of matter, their properties, and the changes which they undergo. Almost everthing with which we come in contact all day long is the product of a chemical process which has either been devised by the chemist or has been controlled by him. Some of the industries in which the chemist plays an important part are: the paint and varnish industry, the production of metals and alloys, the making of dyes, the rubber industry, artificial silk, explosives, leather, and fertilizers.

Specialization

The chemist may become a specialist in either of the two broad classifications of the science: he may become an *inorganic chemist* or an *organic chemist*. Organic chemistry is that branch of chemistry which deals with compounds that contain carbon, while inorganic chemistry deals with the mineral constituents of the earth and the changes they undergo.

Within either branch he may become an *analytical chemist* who, as the name suggests, analyzes both raw materials and

finished products in order to intelligently advise his employer.

Or again, a chemist may specialize in the field of *synthetic chemistry* which is concerned with the building up of chemical products from simpler ones found in nature. Synthetic processes recently have led to the commercial production of synthetic substitutes for natural compounds. Some of these synthetic products are cellophane, lacquers, plastics, new refrigerants, stainless steels, alloys of all kinds, fertilizers, rubber, anti-knock compounds for gasoline, anti-oxidants for rubber, and many household commodities. Young chemists with good training and vivid imaginations will find this field of endeavor both fascinating and lucrative.

Commercial research is a field that offers an individual an opportunity to bring into his work all the talents of an inventive nature that he may possess. He uses both analytical and synthetic chemistry in an endeavor to improve products, to utilize by-products, to create new products, and to reduce waste. His work is chiefly the elaboration of new ideas for the advancement of the industry in which he works.

There are some splendid opportunities for chemists in the numerous research institutions in this country, such as the various governmental laboratories, the Mellon Institute for Industrial Research, the Rockefeller Institute for Medical Research, and many other such organizations. Young chemists who possess research ability have available an extremely fine opportunity for interesting and productive employment.

The *consulting chemist* is one who maintains a private laboratory, and is called upon for advice. Many plants are not large enough to warrant their employing chemists and chemical engineers of their own. Therefore, whenever difficulties arise which require the services of a man trained in chemistry, the consulting chemist is brought into the problem to aid in its solution. Some very important and highly specialized research work is done by this group.

Then again, a fairly large number of men trained in chemistry and chemical engineering use their training merely as a background for purely *executive positions*, or for *sales work*. Many large companies that produce and distribute chemicals, medicines, hospital supplies, and other such materials have need for young men and women with a training in chemistry, even though this work may be of an executive or sales character.

The *teaching field* is one that is open to those who demonstrate

ability in imparting knowledge and who are capable of creating enthusiasm among students for a career in the chemical field. In entering this field the young teacher must realize fully the responsibility which he is assuming, for from his students will emerge the chemists of the future.

Chemical Engineering

So much for chemistry and several of its sub-divisions. We come next to the work of the chemical engineer. One may appropriately inquire at this point as to *which industries employ chemical engineers*. As a matter of fact, all industries in which materials undergo a chemical change or a series of chemical changes are considered chemical industries and usually employ both chemists and chemical engineers. Examples of chemical industries are the manufacture of soap, leather, rubber products, steel products, gasolines, dyes, and explosives. The materials from which these products are made are obtained from nature, and the chemical reactions that they are made to undergo in producing the finished goods are known as chemical processes.

The utilization of these chemical processes in manufacturing has called for men trained to handle engineering problems of a distinctly chemical nature. Therefore, a separate branch of engineering was developed which is called chemical engineering.

Now, there are certain operations which are common to many chemical industries. Some of these are crushing and grinding, evaporation, distillation, filtration, drying, and mixing. These changes in the materials that are not chemical in nature but purely physical are known as *unit operations*. Similarly, in the chemical industries there are certain chemical processes which are common to many of them. For example, nitration, sulfonation, oxidation, reduction, saponification, and hydrolysis. The chemical engineer calls these the *unit processes*. *A chemical manufacturing process may, therefore, be regarded as a co-ordinated series of unit processes and unit operations*. The chemical engineer must be familiar with these and be able to adapt them to the particular chemical industry in which he finds himself employed. To the casual observer it may appear that these are fairly simple and obvious procedures, but in their application in the chemical industries such is far from being the case. In the first place, there are certain fundamental laws involved in every one of the unit operations; there are many possible ways of carrying out each of them; and there

are all sorts of chemicals to be handled, some of which are corrosive, some poisonous, some volatile, and some inflammable.

The chemical engineering profession offers many branches of service. A large number of graduates enter the *production field* of the chemical industries. Their duties are many and varied depending largely on the size and nature of the industry in which they are employed. Some of these duties are in the line of *general plant work of a routine nature*, *sales engineering*, *contact work*, or *plant development*.

The chemical engineer engaged in production work is considered the connecting link between the chemistry research laboratory and the factory. It is his job to convert the chemist's laboratory discoveries into large scale processes which are efficient and which will produce profits.

Chemical engineering begins in the laboratory and proceeds by steps from laboratory apparatus through to the pilot plant —which is a small-scale plant used for testing purposes—and finally to the selection or design of equipment for the full-scale operation of the developed process.

Then again, many find the field of *sales engineering* a very fascinating field of endeavor. Here a man becomes acquainted with many industries. In selling equipment for carrying out the unit operations he utilizes his knowledge of chemical engineering principles, and aids the chemical industry in selecting the most appropriate and efficient piece of equipment that will meet its needs. The sales engineer first acquaints himself with the operation to be carried out, and then makes whatever tests are necessary to give him a complete picture of the chemical and mechanical requirements. Next, he either selects or designs the piece of equipment, supervises its installation, and then teaches the plant workers how to operate the machine. He then proceeds to his next assignment, which will probably be in some other industry or in some other part of the country.

Contact work, as the name suggests, consists of maintaining contacts with the various chemical industries and keeping them informed about the latest developments concerning the products and equipment manufactured and distributed by the company that employs the contact man. He is always on the alert to receive suggestions and criticisms that will materially improve his product. He really advertises the product and does no actual selling.

Another branch of service in the field of chemical engineer-

ing is *research work*, or *plant development work* as it is called. Chemical engineering research, as distinguished from purely chemical research, is directed toward the improvement, control, and better co-ordination of the unit operations and the selection or development of the equipment in which they are carried out. Its chief aim is to provide and organize the means of conducting a chemical process so that it shall function safely, efficiently, and profitably.

A TEACHING DEMONSTRATION OF THE MONOHYBRID CROSS

By Paul F. Brandwein

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The visual aids generally used in the teaching of high school and college genetics resolve themselves into charts, blackboard illustrations and mounts of various sorts. The following description is of a demonstration used succesfully by the writer in high school and college classes.

The idea depends on the reactions of an indicator, phenolphthalein in the presence of acids and alkalies. The indicator turns a deep pink or rose-red in sodium hydroxide and is colorless in acetic acid.

Three inch cuttings of $\frac{3}{8}$ inch red rubber tubing are prepared as follows:—A three inch piece of glass tubing is inserted tightly to fit the rubber tubing. Absorbent cotton is pushed in at one end of the glass tube, and a bead of sodium hydroxide is forced in at the other end. Cotton is then pushed in at the bead end so that the sodium hydroxide is finally enclosed by two plugs of cotton, one at each end of the tube. White rubber tubing is treated in the same manner except that the sodium hydroxide bead is omitted. Before use, a few drops of a 5% acetic acid solution are added to the cotton in the white tube. Seven vials or jars, each of a suitable size to hold two of these rubber tubes are also necessary. To these jars are added tap water and 5 cc. of a 2% solution of phenolphthalein in alcohol enough to cover the tubes.

With the customary chart or drawings of a monohybrid cross between a pure red and white flower, the demonstrations are begun. When two red tubes or "chromosomes" are placed

in a jar, the contents turn deep red because of the reaction of the sodium hydroxide on the phenolphthalein. When two white rubber tubes are placed in another jar, the contents of the latter remain colorless or a cloudy white since phenolphthalein is colorless in acid. It may be readily seen that when one red "chromosome" (red tube) and one white "chromosome" (white tube) are placed together in one jar that the "factor" for red will be dominant, due to the greater concentration of sodium hydroxide. That is, the solution will be colored red. Only when two white "chromosomes" are together, will the solution remain white. The "zygote," then, has two "factors" for white. Thus if the "chromosomes" are disposed as in the cross, the results may be diagrammed as follows:

DIAGRAM I

Homozygous red — Homozygous white

P_1 — Na OH/Na OH — HAC/HAC

(*R*) (*R*) — (*r*) (*r*)

Hybrid red

F_1 — NaOH/HAC

(*R*) (*r*)

Thus two red tubes in one jar and two white tubes in the other, the former containing the bead of NaOH, the latter the few drops of acetic acid, result in the two homozygous or pure parents. When one "chromosome" for each parent jar is lifted by means of forceps from the jar and added to another jar, the hybrid red is produced. It can be seen that if two hybrids are crossed, that a 3:1 ratio of three reds to one white will result.

Thus—

DIAGRAM II

		Female Gametes	
		R HaOH	*r* HAC
Male Gametes	*R* NaOH	NaOH / NaOH *RR*	NaOH / HAC *Rr*
	r HAC	HaOH / HAC *Rr*	HAC / HAC *rr*

It may also be seen that back-crosses can readily be accomplished. In addition, this method is adaptable to use in the demonstration of the significance of reduction divisions.

One precaution must be taken. In the transfer of the "chro-

mosomes" the white ones should always be transferred first so that contamination with strong alkali is avoided. It is advisable to use forceps for the transfer and to wash the tubes before each transfer so that no contaminating chemicals are introduced.

In practice, it is advisable to prepare a few dozen of each chromosome and keep them in boxes. It is not necessary to mate four hybrid "zygotes" to obtain the different "gamete" combinations. One "zygote" i.e. (diagram I) is demonstrated, and the other gametes for the monohybrid cross (diagram II) are taken accordingly, from the boxes. It may be necessary to wait a moment before the reaction sets in. Different teachers, will perhaps, desire to modify the concentrations of alkali and acid so as to obviate the necessity of washing. Thus it is desirable to moisten the cotton in the red tubes with 5 cc of 5 *N* sodium hydroxide, and the cotton in the white tubes with 5 cc of 2.5 *N* acetic acid. The sodium hydroxide in the red tube is then twice the strength of the acetic acid. This obviates washing and removes the error of introducing strong alkali into the acetic acid jar on a back-cross.

PHYSICISTS URGED TO STUDY GIANT MOLECULES TO AID CONQUEST OF THE MYSTERIOUS VIRUS DISEASES

The man who first showed that the mysterious disease-causing viruses are merely giant chemical molecules, despite their ability to reproduce and to exhibit the properties of living things, today urged that the physicists show as much interest in the study of such giant molecules as they do in splitting the atom in the popular realm of nuclear physics.

Dr. W. M. Stanley of the Rockefeller Institute for Medical Research at Princeton, N. J., was the man. The goal he held up to his fellow scientists was the solution of the mysterious viruses and the conquest of the dread diseases they cause; rabies, encephalitis (sleeping sickness), poliomyelitis (infantile paralysis), yellow fever, and the common cold. Other virus diseases also include hoof-and-mouth disease, dog distemper, measles, certain tumorous growths and several mosaic and yellows diseases in plants.

Speaking at the Symposium on Biophysics at the University of Pennsylvania, Dr. Stanley paid tribute to physical methods for the first isolation of the first virus—that of tobacco mosaic. Only by the tremendous centrifugal forces created in swift-whirling centrifuges was the isolation possible of the heavy protein molecules, which cause the mosaic disease in tobacco plants. The probable molecular weight of these giant molecules, said Dr. Stanley, is about 17,000,000. For comparison the molecular weight of the element oxygen is 32. And even the heaviest element known—uranium—has a molecular weight of only about 476.

NATURE RECREATION IN BUFFALO

By William Gould Vinal
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I. In the Beginning

When the Pilgrims set foot on Plymouth Rock acquaintance with the Erie shore was a matter of inference and tradition. Beech-maple forests were in the valleys. Oak-hickory stands with a scattering of elm and now and then a "prairie opening" were to be found on the hills. Birch was abundant at Tonawanda. Hemlock and White pine increased toward the north. The scream of the panther occasionally broke the stillness. Black bear prowled in the shadows and wild turkeys sought wild fruits. To the east were the Iroquois and to the West the Eries. The fires of the Erie were put out by the Iroquois between 1640 and 1655. The more adventurous French traders sometimes took pot-luck in the "buffer state."

In 1788 the Indians and Whites held council on Buffalo Creek. Honayewas, the War-Chief of the Senecas, was there. Sometimes he was called "Farmer's Brother," receiving the name from George Washington who wished to make agriculture respectable among the red men. And there was "Red Jacket" the Chief-Sachem and orator who also lived on Buffalo Creek. The British influence from Canada was strong and by 1791 there was great uneasiness and depredations among the Indians. Col. Thomas Proctor, a commissioner from the United States War Department, was sent to persuade the Senecas to stop their hostilities. While here Proctor had a good meal of young pigeons. Of course he could not visualize that the day would come when these pigeons would be entirely exterminated by short-sighted man.

Cornelius Winne, a Hudson River Dutchman, was the first white settler (1789). He set up a trading post in a small log house. By March 1, 1803, there were enough settlers to hold a town meeting. A bounty of $5.00 was offered for wolf-scalps and half price for "whelps." The important means of winter travel was by snow shoes. "Plumping Mills" for grinding corn were made by scraping out burnt stumps. A "Spring pole" was fastened to a large wooden pestle to pound coarse meal. Once a week a few letters were brought in saddlebags from Canan-

daigua (1804). If a new arrival came from New England or elsewhere the neighbors gathered on a certain day for a house-raising. Social cooperating began in Colonial days. Saddles and notches were cut near the ends of the logs to fit the corners. The rafters were made of "Poles." Ash "Shakes" were cut with cleavers and smoothed with draw shaves for shingles. The chimney was plastered with mud. Until pasture land was cleared the cattle had to eke out an existence by "browsing" on tender twigs. Pork was the "standby" and beef was a luxury. The bears also liked hogs and the wolves had a fondness for sheep. Flax was grown for linen and the "Sugarbush" furnished sweets. For recreation there were husking bees, quilting parties, and sleigh rides on ox-sleds. Nature furnished all. Life consisted of working with nature.

Then came the War of 1812. The British and Canadian Indians burned the villages of Buffalo. Refugees took flight along the Big Tree Road. The Niagara Frontier was smoldering in ashes. In 1815 the news of peace came and the reconstruction of Buffalo began. Buffalo was off to a late start. But nature was kind. Buffalo was at the crossroads. Nature's gifts were abundant. These "gifts" were to be brought to the "crossroads" to build a great metropolis.

II. The Buffalo Society of Natural Science

Dr. G. Brown Goode, Director of the United States National Museum, once said, "The people's Museum should be much more than a house full of specimens in glass cases. It should be a house full of ideas, arranged with the strictest attention to system." The Buffalo Museum of Science has more than filled Goode's requirements. Instead of a collection it is an illustrated story. Administered by the Buffalo Society of Natural Sciences the Museum has affected the nature culture, the nature recreation, and the nature education of Buffalo more than any other institution. It has attracted the attention of scientists, both at home and abroad. A few landmarks will show the services of the society to the community during the last seventy-five years.

The Buffalo Society of Natural Science was born in 1861, but not by accident. As early as 1859 ten boy scientists met from house-to-house to discuss the first chapter of Genesis, and such books as Dr. Edward Hitchcock's *Religion of Geology* (1851), and Darwin's *The Origin of Species* (1859). The present organi-

zation was finally incorporated (1863) with most of these youths as charter members.[1]

The first custodian for the Society was Charles Linden (1831–1888). Born in Breslau, Germany, he was self-taught in the book of nature. Spending his early days as a sailor he drifted to the port of Buffalo. His roving spirit later sent him to Haiti, Brazil, and Labrador where he collected summers for the museum. As science teacher at Central High School he was loved by all his pupils who in 1901 placed a bronze tablet on the walls as a memorial.

Augustus R. Grote (1870–1903) succeeded Linden for another seven year period of curatorship. His interest was entomology. In 1879–1880 he edited the *North American Entomologist.*

From the beginning there has been a long list of prominent men associated with the Society. Millard Fillmore and Grover Cleveland were on the roll. Is there any other Natural History Society that can boast of two presidents as members? Judge George W. Clinton, son of Governor DeWitt Clinton after whom Clintonia was named was the first president (1861–1881). Judge Clinton built up an herbarium of 24,000 species which in itself is a testimony of industry and an unselfish spirit. Ottomar Reinecke (1840–1917), head of the Buffalo *Free Press*, was a member of the Buffalo Society for about fifty years. Ever since he was a small boy in Germany, Reinecke was interested in nature. His home was that of a naturalist. He had over a hundred cases of birds and thirty drawers of eggs which he delighted to show visitors. He had twenty-two of the twenty-six species of wild ducks and other species in like proportion. His "museum" was one of the finest of ornithological collections.

It will be noted that many of the early leaders of the Buffalo Society of Natural Sciences were Germans. By 1880 one-half of the population of Buffalo was of German descent or were German born. The early school-training of the latter in natural sciences was probably no small factor in bringing about the early accomplishments of this notable organization. It may be for this reason that the society first cooperated with the schools as early as 1879.

According to the will of Dr. Hayes in the early eighties "a school of science was to be established." He like many another benefactor had faith in its future. Julius Pohlman, Director of

[1] Most of the statistics are taken from *Hobbies*, December, 1926. Historical sketch by Henry R. Howland (1844–1930) who, for over sixty years, gave service to the Buffalo Society of Natural Sciences.

the Museum, in his report in the same bulletin,[2] speaks of the Agassiz Association Chapters which include "Girls and boys ranging in ages from ten to eighteen. I leave it to the consideration of the members of the Society whether a careful fostering of the inquiring spirit of these young people will not, in the end, prove advantageous to the interests of the society. . . . It is a great pity that the schools of our city, public as well as private, do not avail themselves more of the advantages offered by the museum—although natural science is taught in more than one of our schools." He might have been saying this today instead of over 50 years ago.

By 1902 there were nature talks for the grades, a series of trips for the teachers, and traveling exhibits were sent to the schools.[3] The first projection lantern owned by the society was used to illustrate talks on nature by the principals and teachers. The Saturday afternoon illustrated lectures on "Birds" and "Bees" became so popular that the Department of Public Instruction accepted the plan as proposed by the Society as a regular course of events and attendance was required. The program was based on the state syllabus. By 1905, Dr. Carlos E. Cummings had entire charge of the children's work. The Buffalo Society claims to be the "first natural history association in the United States to formulate and put into operation direct contact with the children of the public schools through arranged lectures for school children." The practice, first instituted in 1901, has now been adopted by practically all the great natural history museums in this country.[4]

In 1912 the eighth grades were using *A Watcher in the Woods* by Dallas Lore Sharp as a text. The Museum had a children's corner of special interest and instructions and the lectures to the children were based on this book.

The Buffalo Society of Natural Sciences took on a new lease of life in 1920 when Chauncey J. Hamlin was elected to the presidency. Returning from the World War he consistently devoted his time to civic service. Honors have been heaped upon him both locally and nationally but through it all he has been loyal to his first adoption—the Society of Natural Sciences. Formerly President of the Buffalo City Planning Association (1920–1929)

[2] Buffalo Society of Natural Sciences, *First Bulletin of the Society* (p. 17), 23d Annual Meeting, February 22, 1884.

[3] *Buffalo Express*, May 8, 1902.

[4] *Hobbies*, Buffalo Society of Natural Sciences, February, 1923, pp. 1–2. *Hobbies* has been published since 1920.

he resigned to give time to the Museum. He was president of the American Association of Museums (1922–1929) and in 1924 was chairman of the National Conference on Outdoor Recreation organized at the call of President Coolidge. He was the fifth man to win the Chancellor's Medal (1930) awarded by the University of Buffalo for his part in "dignifying Buffalo in the eyes of the World." Again, he received the Pugsley Gold Medal for services in establishing Allegany State Park (1933) and for coordinating national movements for outdoor recreation and natural history education.

In 1922 the State Legislature passed an act giving the city "discretionary authority to provide a site and furnish money for . . . a building." In this year it is interesting to note that the museum loaned 372,900 lantern slides free to the public. Neighborhood lecture courses in 10 outlying centers were attended by 43,000 individuals and during the winter months there was an average of 30 lectures a night. In 1928 the Society entered into a contract with the city whereby it became a public museum. In 1931 there was a staff of 85, an annual budget of $185,000 and a million dollar building. Unfortunately the city's appropriation for 1936 has been reduced by 63% and the staff has been reduced to 41.

The new Buffalo Museum was dedicated (1928). Its program brings the city distinction. Doctor Herman C. Bumpus has been associated with the Buffalo Organization since 1925 and had a considerable part in its expansion prior to occupying Humboldt Park. The building is the last word in Museum arrangement and serves as a model for other municipalities.[5] The arrangement is unique in that the exhibit halls give a resumé, or connected-story-in-brief, of natural history. Ten smaller halls lead to a more detailed study of such interesting phenomena as rocks, the beginning of life, life of waters, plant life, insect life, and finally man. Then too there is the exhibition of the machine age, the Knox Evolution of Money collection, a Hall of Conservation now in process of development, and everything else one would expect in the "Lively" museum. The Buffalo Museum is an exciting place. It influences not only the city's thoughts in nature but such other cultures as art, history, gardening, literature, and music. It enters into the Buffalonians daily life whether working, eating, sleeping or playing—the Buffalo Museum is always with him.[6]

[5] See *Hobbies*, February, 1923, for details and plans.

[6] *How the Buffalo Museum of Science Serves Youth and the Adult.* A Museum publication, 1929 22 pp.

It is unfortunate that the purport of this article will not allow an extended story of each of the celebrated members of the Museum's staff. There is Dr. Elizabeth J. Letson, who, in her time, was the only woman director of a large museum, who compiled a check list of the Mollusks of New York (1905) for the State Museum at Albany. Then William P. Alexander, who with Maribelle Cormack gave us that delightful story *The Museum Comes to Life* in which the "Inhabitants" of a museum (presumably the Buffalo Museum) are viewed by a small mouse who listens attentively to their life histories. In *School and Society* for May 1928, Sherman C. Bishop, Zoologist of the New York State Museum at Albany, comments on the nature trails which W.P.A. established in the Allegany State Park as a "Pioneer attempt along lines that have since developed far and wide in various parts of the country." And Dr. Charles J. Fish (Brown, 1921) who came to direct the Museum at the youthful age of 27 years, was one time member of William Beebe's Arcturus Expedition to Sargasso Sea (1925), in charge of the Survey of Fish Conditions in Lake Erie (1929) and named by the U. S. Government and Canada as Executive Secretary and biologist of the joint international fisheries survey of Passamaquoddy, Maine to determine the effects of a proposed power dam upon the herring industry (1931). And Mrs. Fish (Smith, 1921) as though not to be eclipsed by her husband, discovered the eggs of the common American eel 10 miles S.W. of Bermuda. Before this scientists had known that eels migrate down streams in the fall to spawn in salt water but *where* had been a mystery. There is the wonderful art work of Henri Marchand, and so on down to the present Director, Dr. Carlos E. Cummings, a graduate of Syracuse and a medical degree from the University of Buffalo (1903) who takes splendid photographs and won the Museum distinction for children's work. Perhaps this is a good place to stop. But no—we must at least mention that the Buffalo Society of Natural History in cooperation with the local Board of Education and the Buffalo State Teachers College has offered Credit Courses. And the Allegany School of Natural History (1927) in cooperation with the New York State Museum and the University of Buffalo which gives college credit is a summer shrine for teachers who wish to equip themselves in knowledge of the out-of-doors. The Buffalo Society of Natural Sciences has done noble service for three quarters of a century. The community should put a wreath on its crown and 75 candles at its feet in the form of an endowment

rather than presenting it a birthday cake that's been 63% cut, with no frosting and a false filling, ex-staff members set adrift in a boat without food or drink, and without chart or compass.

III. The Buffalo Schools and Nature Study

When Sir Daniel Hall, British Agricultural Scientist recently told the British Association for the Advancement of Science that "men of science must leave their ivory tower and join in the common fight for freedom" he could not have had the million dollar Buffalo Museum in mind. It was because the Buffalo men of science have always fought for the commonweal along the Niagara Frontier that the proposal for a Museum brought before the people for referendum went over so handsomely. Buffalo scientists and the Buffalo Museum have served par excellence.

Hiram Hanchett taught the first school (1806–1807), Jesse Ketchum owned the land where the first school house was built (1809) and is said to have prompted the idea. Buffalo claims to be the first city to establish the office of Superintendent of Schools (1836–1837). Roswell Willson Haskins received the appointment but was an official without power.[7] Unlike most Boards of Education the members are appointed by the mayor and the Board is organically connected with the City Government. So much for the beginnings of education and the physical background.

Many Buffalo school men have been first class naturalists. Frederick Vogt, Principal of Central High (1892–1919), received an honorary degree from Colgate (1908) for his enthusiastic interest in botany and zoology, especially birds. In his report for Central High he said that "our Geology and Botany Classes all make *required* excursions. We have done this for years."[8] Frank S. Fosdick, Principal of Masten Park High School in the second annual report for that high school[9] speaks of an annual excursion to Portage of about 1000 scholars who "passed a delightful day amid the beautiful scenes of the famous Portage Falls. It is a good thing—to get into close touch with nature and become acquainted with her beauties." The early High School Principals were nature minded to the point of doing something about it.

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[7] *Municipality of Buffalo, N. Y.* H. W. Hill, Editor, p. 503.
[8] *Annual Report of Superintendent of Education*, 1897–1898, p. 56
[9] *Annual Report of Superintendent of Education*, 1898, p. 57.

Henry P. Emerson (1846–1930), a Buffalo teacher (1873–1893) and later elected Superintendent of Education (1893–1918) on the Republican ticket was president of the Buffalo Society of Natural Sciences (1892–1893). On March 18, 1898 he spoke before the Society on "The Place of Nature in Education." His annual report for 1897 contains significant beginnings.[10] *Vacation Schools* evidently started in 1898 in School No. 2 (an Italian District) and in No. 44 (a Polish District). 200 teachers volunteered their services. Books were dispensed with and although the teaching was mostly manual, nature study was included in the program. Trips were made to the parks, Niagara Falls and other points. Adjoining page 112 may be seen a picture of a "barge" and a pair of horses which was the means of transportation. According to that report Home Geography had a place in the curriculum. "In teaching the facts of physical geography, the statement of the famous German geographer, Ritter, 'Wherever our home is there lie all the material which we need for a study of the entire globe,' and Humboldt's equally significant saying, 'Every little nook and corner is but the reflection of the whole of nature' furnish the key to the proper method." Emerson's Course in *Physiology and Hygiene* also had directions which were familiar in nature study. "The instruction in this subject is to be entirely oral—So far as possible, let the teaching be objective; let the children see and handle the material brought in for illustration. Remember that the natural method of acquiring scientific knowledge is through observation and induction." Emerson goes on to say that in the primary grades science lessons are designated "Observation lessons." He says that "detailed instructions will be given at grade meetings and through circulars. The results to be derived from the right study of elementary science are many and important, and the purpose of introducing this branch into the regular course of study is to accomplish these results to the greatest degree possible." His objectives may be listed as follows:

Opportunity of knowing the individuality of pupils.
Pupil's senses are exercised and rightly trained by observations.
Pupil's intellectual faculties strengthened.
Pupil's power of expression refined.
Pupil's morals being nourished.
To know truth, to respect divine laws and to know interdependence.

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[10] *Annual Report of Superintendent of Education*, 1897–1898—Vacation Schools, p. 111.

Superintendent Emerson's Annual report for 1902–1903 had about three pages devoted to the outline of the Course of Study for the Primary and Grammar Grades. In the primary grades he now designates the science lessons as "nature study." He recommends Hodge's *Nature Study and Life* as helpful. In his report for 1904–1905 Nature Study comes into its own with seventeen pages. "Nature study is a welcome addition to the primary course of study, if properly conducted.—The following outline has been taken from the very helpful syllabus prepared by the State Education Department. Every teacher will find it possible to carry on some part of the work outlined for each term; many will do it all." It was called Agriculture in the 6–8 grades. The *Grammar School Text Books* (12th year since introduction of Free Books) listed 4020 copies of Bass' *Plant Life* and 3111 copies of Burrough's *Birds and Bees*. Interspersed with the outline were excellent suggestions for teachers, such as: Presence in the school room of living material, frequent excursions, children see better if they draw—much time may be wasted by too much drawing, plant seeds, experiment, conversation lessons, observations accurate but not complete, avoid definitions, spontaneity of work, interdependence rather than facts, and principles rather than facts alone. He explains at length that information is no longer a measure of success and that more attention must be given to character and health. As far as practice is concerned Superintendent Emerson's theory would be timely today. It is thus seen that Nature Study did not spring up over-night in the Buffalo School System. It was gradually built up to a course of study over a period of eight years. Recognition came from Benjamin R. Andrews, Supervisor of the Educational Museum of Teachers College, Columbia University[11] when he "asked the Buffalo Society to prepare a detailed report of its work in cooperation with the School Department."

The "Dean of Nature Study in the Buffalo Public Schools" is Frederick Houghton, Principal of School 69, which is in a community that is made up almost entirely of Polish people. Perhaps that is the reason for his interest in Americanization. In 1902 Principal Houghton gave a paper on "The Value of Traveling Exhibits in Archaeology" before the summer meeting of the American Association for the Advancement of Science in Pittsburgh. In February 1904 he had an article in *American Educa-*

[11] *Buffalo Express*, February 19, 1906.

tion on "Cooperation of Museums and Schools" as a "powerful factor in public education." His cottage at Springville, with its wildflower garden, overlooks the historic Zoar Valley. The Society of Natural Science selected him to trace the source of the Seneca Indians and his book on the *Seneca Nation* probably won for him the Cornplanter Medal for Iroquois Research (1923). It is roughly estimated that there may be 38 schools that have one good nature teacher. It is safe to say that for the most part they were trained at the Natural History Museum. We will let Mr. Houghton stand as representative of the group—perhaps not a militant champion for the cause but one who appreciates the values that it offers.

The amazing thing is that if nature study was "eased into the curriculum" it was also "oozed out" and was done so quietly that no one today can remember how, when, or why it was done. Up to and including the 1909–1910 report of the Superintendent of Education the report for 1904–1905 on Nature Study was practically duplicated. In the 1910–1911 report the following statement is made: "The New York State Syllabus of 1910 made some radical changes in the elementary course of study . . . a simple and attractive course in elementary science made up of suitable experiments has been prepared." There is no other record. The rest of the story is left for you to guess. The Supervisor of German with his 48 special teachers remained. In the 1917 report, with Dr. H. P. Emerson still superintendent, there are reports by the supervisors of drawing and by the Directors of Music, Gymnastics, Manual Training, Penmanship, and Domestic Art but not of science. In 1924 E. C. Hartwell, Superintendent of Schools, issued a 28-page pamphlet which apparently had the purpose of acquainting parents and the public in general with the changes in method. On page 18 of that pamphlet there appears the picture of a sixth grade lesson in the study of birds which implies that nature study is given during the spring months. L. H. Weir's Recreation Survey[12] makes special mention of the fact that the system does not allow hikes except on off hours and intimates that it still relies on the printed word and academic instruction. The Buffalo School Survey in 1930[13] says that "Nature study or elementary science is not listed, except that which is included in geography." In 1936 I find it submerged in the social sciences. There is good evi-

[12] L. H. Weir, *Recreation Survey of Buffalo*, 1925, pp. 369.
[13] *Report of the Buffalo School Survey*, Dec. 1930, p. 48.

dence then that nature study in Buffalo has been under a Laissez-faire (or Lazy fairy) policy for the past 36 years. That is surprising when one realizes that Buffalo's large neighbors —Rochester, Pittsburgh, Cleveland and Syracuse have nature study or elementary science in the curriculum and under supervision.

The Buffalo Teachers College is an important cog-in-the-wheel that makes nature recreation possible for Buffalo children. For the past few years the college has been working on a program of science instruction for the elementary classroom teacher. Two years of informational, unspecialized science instruction is required in the program. The course called "Field Studies in Science" is specially helpful in this preparation. Elementary science is taught in grades 1–6 of the Practice School and General Science in grades 7–9. This work is available to local teachers for observation. This program is under the leadership of Dr. Anna Gemmill, who recently obtained her Ph.D. from Columbia University, all of which bodes well for progressive leadership in this field.

IV. The Buffalo Parks and Nature Study

The village of New Amsterdam was laid out in 1804 by Joseph Ellicott. The liberal width of Delaware Avenue is due to his foresight.

In 1868 Frederick Law Olmstead was brought to Buffalo at the expense of several public spirited citizens. William Dorsheimer was a member of this Committee. In 1869 the Board of Park Commissioners authorized a bond issue of $500,000. William McMillan, a landscape gardener and horticulturist, was made the first superintendent. He served for nearly thirty years.

Olmstead prepared a map (1876) to show the design of three new parks and their approaches. This map was exhibited at Philadelphia (1876) and Paris (1878). The Buffalo Park System developed in accord with this plan.

Delaware Park was purchased in 1870. In 1886 the Park Commission purchased 182 sheep both for fertilization of the meadows and for the development of the natural surroundings. In 1903 they purchased squirrels to add to the natural beauty of the parks. The old quarry was transformed into a beautiful garden. These factors were unfortunately used for mere entertainment rather than instruction.

In 1908 the care of all trees in streets and public places was assigned to the Park Department and a Department of Forestry was established. The City offered 10¢ a quart to children for eggs and caterpillars. The report doesn't say whether the children obtained a better measure by hatching the eggs and rearing the caterpillars. Many of the trees were labeled.

In 1894 Olmstead furnished plans for a Botanic Garden in South Park. John F. Cowell was elected Director and served until his death in 1915. This is said to be the only Botanic Garden which is financed solely by Municipal appropriations.

Today the City Parks amount to 1981 acres. There are 60 playgrounds, 37 are under the Board of Education and 23 are under the Park Department. There are still districts without a single playground. The activities are mostly athletic with apparently no consciousness of the possibility of nature recreation.

The Erie County Park Commission is known for its progressive work[14] especially in Nature Lore. In 1932 the County Park Nature Trails were started under the direction of Professor William P. Alexander of the Buffalo Museum of Science.

Emery Park, near East Aurora, has regular trips led by Miss Mabel E. James, Park Naturalist. At the Emery Park Inn there is a Nature Room and a Museum with relics of Colonial and Civil War Days. There are 75 varieties of lilacs, a formal garden, and a nature trail through a beautiful wooded ravine. The work of Miss James is sponsored by the State Education Department and the Garden Center Institute of Buffalo. These organizations and the Garden Club of East Aurora (Mrs. E. B. Holdredge, President) in the spring of 1936 initiated a nature trail on the Village Wild Life Sanctuary which consists of 77 acres of woodland and swamp. Miss James is also the nature guide for this project.

Como County Park has a Muskrat Colony, Alaskan reindeer, and a nature trail sponsored by the Lancaster Garden Club.

Chestnut Ridge Park, like the other County Parks, is a bird and game refuge. Rabbits and pheasants are bred and released and the winter feeding of birds is another regular activity. The new Casino at an estimated cost of $93,000, to be finished by 1937, will have a museum in one wing. William W. Lewis plans to loan 1000 birds nests and Mr. Thuman, taxidermist, is offering a collection of native birds which he will arrange. All of this implies a resident naturalist for Chestnut Ridge Park. The

[14] See Erie County Parks in index of *Parks: A Manual* by L. H. Weir, Barnes Co., 1928.

aim of the County Parks, to provide for the appreciation and enjoyment of the outdoors, is being realized and is indicative of trends in other Metropolitan Parks.

The Oglebay Institute of Wheeling, West Virginia has a planned program. The annual report of the activities of the Ogelbay Institute and the Wheeling Park Commission of the Wheeling Metropolitan area has just come to my desk.[15] Nearly a score of recreational activities are embodied in the report. Participation in 1936 in the upper brackets are as follows: Picnics (1505), 20,269; Nature Field Trips (88) and Lectures (52), 19,504; Mansion-Museum 18,116; Nature Museum (Est.), 12,000; Golf (rounds played), 11,277; Concerts, 10,749. It would appear from analysis of the report, that nature activities rank high in Wheeling. People are as apt to go on a nature trip or to a nature lecture as on a picnic. To quote from the *Bulletin* "demands upon the Institute nature program compelled the employment for three summer months of two assistant naturalists in order to adequately meet public requests." It is undoubtedly true that with the recent increase in Metropolitan and County Park areas that there has been a phenomenal growth in nature activities.

The Erie County Parks are endowed natural areas. The County Park Commission is setting up physical advantages and activity programs, that bid fair to compete with public dance halls. Weir's Survey shows that less than half of the recreation of children is in the home. He also found that sitting-down recreation is claiming more time than the more invigorating outdoor activities. Erie County children must be educated parkward to gain the same fundamentals that were inherited by the children of earlier days. The automobile is bringing the County Parks under the class of doorway-playgrounds. The wholesome programs of the County Parks will make a difference. They are examples of planned nature programs.

V. A Planned Nature Program

If George Washington had told "Farmer's Brother" that there is ten times as much wealth in the soil of the Niagara Frontier as he was getting out of it he wouldn't have understood it. If certain City Fathers were told about the lighted schoolhouse, the lighted playground, and the lighted museum they wouldn't understand and they certainly wouldn't advance the

[15] *The Oglebay Institute Bulletin*, Oglebay Park, Wheeling, W.Va., November, 1936.

money. They are thinking in terms of a lighted street. The philosophy of Regional Planning has gone over in a big way in Buffalo in the form of the Niagara Frontier Planning Commission and the City Planning Commission. A "Planned Community Life" does not receive so much attention. Cleveland has cooperated for years in one centralized Community Chest but Buffalo has not reached the stage where it can look through the spectacles of Moses Cleveland. Social planning is also a basis of human economy. A few years ago Buffalo built a million dollar natural history museum. Today Buffalo turns around and reduces its efficiency by the slogan "A million dollar monument for dead bugs." If the Museum was good in 1928 it is good now when thousands of additional citizens are lost for want of a leisure time pursuit. Supplying a Museum is a public business. Even a Commission form of Government is not a sacred method of government. It is an experimental form of government which needs study and research. When a plan of action has been proven to be the right course no skilled but uninformed politician should have the power to tear it down. At the present time Buffalo is contemplating a new City-County Zoo which shall be comparable to the wonderful Zoos in Chicago, Milwaukee and San Francisco. If through research Buffalo supports the position that a million dollar zoo is properly a public function then Buffalo must organize to encourage a more intelligent use of the Zoo and not to remove it ten years from now by a political spoils system or by less informed civic leaders. Another slogan that I have heard in your midst is "Less books and more cooks." Of course you have also heard that "Thou shalt not live by bread alone." Don't go ahead with your Zoo if later you are going to say "Fewer elephants and more cows."

I am reminded of a short story in the Paris Miroir du Monde which is printed in the November 1936 *Reader's Digest*. "A roadside sign in Normandy reads 'Pasture your horse here. Short-tailed horses, 10 cents a day; long-tailed horses, 20 cents a day!' A local peasant, asked to explain the distinction, answered: 'A short-tailed horse is bothered all the time by flies. To shake them off he has to use his head and while doing that he can't eat. A long-tailed horse can handle the situation with his tail without raising his mouth from the grass. The men of Normandy would never pay as much for grazing a short-tailed horse as a long-tailed one." The application is evident. A politician who has to use his head to shake off gadflies may eat

less grass but in the long run he is more expensive as he cannot see the fields for the gadflies.

Two local incidents that have come to my attention will again illustrate what I am driving at. On Armistice Day I saw on Clinton Street a dozen urchins with toy pistols and guns. I wondered what the purpose of Armistice Day is and why school had been dismissed. This was an example of unplanned education. Multiply it by all the Saturdays and Sundays and holidays and what will be the results?

This fall a teacher in one of Buffalo's public schools suggested that the children collect autumn leaves. She had fulfilled her duty, as she saw it, which was to mention nature once a year. A little boy went home and said: "At last I have a teacher interested in nature." He collected leaves to show autumn colors and leaves to show the varying appetites of insects. He arranged and mounted the leaves with enthusiasm. The teacher never mentioned autumn leaves again nor did she ask to see what the children had done. There is a scar in that boy's heart that will never heal. Whether or not the teacher knows it, she has lost out. This is again an example of unplanned nature study, for education goes on whether we will or not.

Another local example of progressiveness in science education is the *Buffalo Textbook*.[16] Science has made possible modern industrial Buffalo. It is a story that reads like fiction. It involves the romance of coke, steel, wood pulp, canning, cold storage, pig iron, flour milling, meat packing, coal tar, dyes, rubber, and the largest hydro-electric plant in the world. Tourist travel —the appreciation of the retreat of Niagara Falls—5 feet a year as one of nature's great time clocks—the Allegany State Park—the Chautauqua movement, are nationally known. This is a type of book that should be made available to every child in every city. We are living in a scientific age. We cannot afford to be illiterate in science.

What is meant by scientific research? Suppose the Izaak Walton League or a "Nature Activities Commission" wanted to know if Buffalo is on a par with other cities in a science program for boys and girls. An unbiased research would present the facts regardless of where "lightning strikes." With a new superintendent of schools (Dr. R. T. Bapst) starting with a clean slate, with a new state course in science about to be

[16] *Buffalo's Textbook*, 1928, 223 pages. Authorized by the Council of the city of Buffalo and adopted by the Department of Education for use in the public schools in the study of Buffalo.

printed for the elementary grades and last but by no means least, a move to coordinate Buffalo's program of "Human Affairs" by the Leisure Time Division of the Buffalo Council of Social Agencies, a new era in Nature Activities seems near at hand. The Council and other agencies have made previous attempts to stimulate action but have been handicapped by the amount of staff time available. With the general rallying of public agencies to its banner it is hoped that a full time person can be made available for the leisure time and recreational program. Definite steps have been taken toward this end (Nov. 19, 1936). This effort will pay big dividends.

A committee for a "planned nature program" should study nature leadership and training, the museum, the schools, the parks, the playgrounds, the zoo, the botanic garden, and the greenhouses and bring Buffalo to the place it merits. These activities should be coordinated. Having once determined the policies there must be social insurance. The same committee should be trustees. There is no greater problem confronting Buffalo today.

VI. Buffalo Science Heroes

The values of a course of study in elementary school science; the benefits of gardening as a leisure time pursuit; the need of outdoor schoolrooms, camping, and nature recreation; the necessity for conservation, the recognition of such cultures as furnished by a natural history museum are too well known (or if not known are easily available) to be given space here. In organizing for A Planned Nature Program in Buffalo the Committee would do well to consider "Buffalo Science Heroes."

Andrew Langdon, upon the occasion of presenting a pair of meteorites to the Buffalo Society of Natural Science, said that when a lad he read Bayard Taylor's *Views Afoot*. "The book fascinated me and planted in my boyish mind travel seeds, which germinated, and have largely influenced my whole life, ever a well-spring of joy."[17]

In a city that has risen from ashes since the War of 1812—a city that is scarcely over a hundred years old—there is bound to be the story of the progressive use (not conquest) of nature's gifts and of the local people who had the vision and capacity to make such use of their environment. Such seeds made available to youth, in language that they can understand, may

[17] *Buffalo Express*, November, 1906.

germinate and have influence on their whole lives. This is an attempt to show the possibilities of such a book rather than to present the romance itself. That could be a worthy undertaking for a class in school or for a local club to prepare for "Camp Fire Stories." Consequently only a "brief" is presented of a few typical "Buffalo Science Heroes."

Peter Kalm, the noted botanist, was perhaps the first scientist of note to explore the locality. He was attracted here by Niagara Falls as have been many scientists since his day. A letter from Mr. Kalm, A Gentleman of Sweden, then on his travels in America, to his friend in Philadelphia (John Bartram), containing a particular account of the Great Fall of Niagara was written from Albany under date of September 2, 1750. The letter appears in Bartram's book (p. 79) which is published in 1751 with the following title: "Observations on the inhabitants, climate, soil, river, productions, animals, and other matters worthy of notice. Made by Mr. John Bartram in his travels from Pennsylvania etc. to which is annexed a curious account of the Cataracts at Niagara by Mr. Peter Kalm, a Swedish Gentleman who traveled there." Fortunately this book is available in the library of the Buffalo Historical Society. The ending of the letter is characteristic of scientists. "Here you have, Sir, a short but exact description of this famous Niagara Cataract: You must excuse me if you find in my account, no extravagant wonders. I can not make otherwise than I find it. I had rather it should be said of me in time to come, that I related things as they were."

Judge George W. Clinton (1807–1885) has already been mentioned as the first president of the Buffalo Society of Natural Science. That he held this position of trust for twenty years would suggest that he was not a "mere citizen." For three generations before him his ancestors had been governors and leaders in public service in New York State. When 19 years old, in the spring of 1826, he went on what must have been one of the earliest local scientific expeditions which went from Albany to the Village of Buffalo on the packet boat LaFayette. The party was under the leadership of Professor Amos Eaton, principal of Rensselaer School of Science. Rafinesque was the botanist of the party. Young Clinton was infected with a love of botany as appears in his original notes now in possession of the Natural Science Museum. Botany became his hobby.

His father, DeWitt Clinton (born in 1769) without doubt

fathered the interest and his early associates cultivated it to the point of enthusiasm. For 20 years he practiced law in Buffalo and during this time botany was his recreation. He would go on all-day collecting trips which was a "labor of love" for the Society of Natural Science herbarium. His "Notes of a Botanist" appeared weekly in a local Sunday paper. This interest was not limited to plants. An English author called him "The Isaak Walton of America" and he undoubtedly knew fish better than any Buffalonian of his day. As Judge or Scientist he loved the truth. He rejected Darwinism as he thought that it was speculative science. He must also have been a teacher as the Honorable James O. Putnam once said: "Nature's own child, he has unfolded to us her mysteries, as she has revealed them to him."

Millard Fillmore (1800–1874) should be known as a statesman and not a naturalist. His early surroundings, however, made it necessary for him to rub up against nature. His ancestors for four generations were pioneers in the American forest. Millard himself was brought up in the wilderness, lived in a rudely constructed cabin, and heard the howl of the wolf in the woods. He was a sickly, rustic boy dressed in homespun, went to the common school, and helped his father on the farm in the spring and summer. His father was of limited means. The boy went away "on his own" at the age of fourteen. As a teacher he received $10 a month and boarded around. He not only taught school but practiced surveying and always studied between times. His success was due to heredity, plus work, reading, and thinking. He learned valuable lessons in the school-of-hard-work. All of this may explain his interest and membership in the struggling Society of Natural History. He encouraged every enterprise in his home city—Buffalo.

In the same way that Millard Fillmore conquered his environment so others came and made good use of what they had. William Lautz, Sr. in 1853 came from Germany with seven children and a lean pocketbook. The story of how he made use of the "Fat of the land" to make tallow candles and soap may be outlined in single words, all of which hark back to nature: baskets, handcrafts, dog-teams, horse and wagon, railroads, and ships on the Great Lakes. His work was carried on to the third generation when his descendants became patrons of music and other Buffalo cultures. The growth of the "Larkin Idea" from "Factory to Family" until the plant covered 50 acres

(1907) is perhaps the sequel in soap manufacturing.

Another interesting story is the growth of the Idea of Friendliness. The Erie County Society for the Prevention of Cruelty to Animals (1867) is the second of its kind in the United States. How Mrs. John C. Lord started the Humane Education Committee and talked to the children in every school in the city up to the days of a City Dog Pound and the Animal Rescue League is a period that is alive with anecdotes about dogs, horses, and other four footed friends. How the Schoelkopf Brothers studied Chemistry in Germany for seven years and returned to the home town (1879) to manufacture coal tar dyes is a more recent romance of science.

And today there is Jane Abbott who for four years was Commissioner of the Girl Scouts for Erie County. Mrs. Abbot herself would no doubt be surprised to find herself counted as a naturalist. However, she spends her vacations in the Adirondacks and enjoys the simple outdoor life and her garden. She is an "outdoor girl" who has more love for the outdoors than for a stuffy schoolroom. Her father was a sailor and she spent many vacations on a freighter from Buffalo to Chicago and Duluth. She writes for the 14–15 year old girls who go camping in a sugar house, or grow up on an orange plantation, or go back to the ancestral homestead as in *Bouquet Hall* (1931) or is a tomboy as in *Black Flower* (1929). Her stories are wholesome, inspiring, and full of natural common sense. She wholeheartedly believes in country life as complementary to our modern apartment system and as such should be listed among those who are championing Buffalo's "back to Nature movement."

CHEAP TANNING

Cheaper leather, of better quality, will soon be available to Pacific coast users as a result of studies recently completed by U. S. Department of Agriculture scientists, who have found a method of tanning leather with western hemlock bark extracts.

Formerly a waste product, western hemlock bark was studied by the late Chas. C. Smoot, tanning technologist, in an effort to find a commercial use for the tons of material thrown away during lumbering operations. Tests of the tannin content by numerous manufacturers have shown the practicability of using this bark, native to the west coast, in the tanning of west coast leathers, thereby eliminating long expensive hauls of leather or tannin.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON

State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting, and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

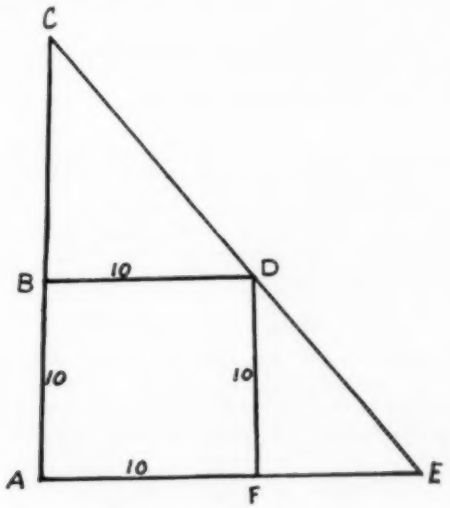
1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

1508. *Proposed by Robert Crookshank, Brookfield, Missouri.*

An upright flag pole 100 feet long was broken and fell across a building, in the shape of a cube 10 feet on a side. It fell so that the broken part rests on the edge of the building, and the end of the pole rests on the ground. If the building stands next to the upright portion of the flag pole, find the height of this part of the pole.



Solution by Charles P. Louthan, Columbus, Ohio.

Let $AC=x$, $CE=y$, $AE=z$

$$x^2+y^2=z^2,\ x+y=100\ \therefore\ y=100-x. \tag{1}$$

From $\triangle BCD$ and $\triangle DEF$, $BC:10=10:FE$, or

$$(x-10)(z-10)=100$$

from which $z=10x/x-10$

By substitution in (1) and simplifying

$$2x^3-139x^2+2200z-10000=0. \tag{2}$$

The approximate solutions of (2) are:

$$x_1=49.2,\ x_2=11.3,\ x_3=9.$$

Only the first two solutions will apply to this problem.

Solutions were also offered by W. R. Smith, Chicago, and the proposer.

1509. *Proposed by Marquess Wallace, Mexico, Mo.*

Two trains on parallel tracks, one running at the rate of 30 miles per hour and the other at the rate of 45 miles per hour, pass each other in 4 seconds where they are traveling in opposite directions. When traveling in the same direction, they pass each other in 80 seconds. Find the lengths of the two trains.

Solution by W. R. Smith, Chicago.

The data given are impossible. In traveling the same direction the rate at which the rear end of the first approaches the front end of the second is 15 miles per hour, while going in opposite directions the rear ends are approaching at the rate of 75 miles an hour. The ratio of the two times is 1:5 rather than 4:80 as given.

Also let x = length of slower train.

and y = length of faster train.

Since rates and time are given for trains to pass,

$x+y=440$ for opposite direction and

$x+y=1760$ for same direction.

These conditions are inconsistent.

The time required depends upon the sum of the lengths and rates, irrespective of the individual lengths.

Mr. Trigg in his similar conclusion mentions that the problem is found on page 89 of Hawkes-Luby-Touton "Second Year Algebra" (1935 enlarged edition). The answers given are 610 for fast train and 1150 feet for slow train.

A solution by E. A. Bahabunmi, Monrovia, Liberia, was offered.

1510. *Proposed by Neil Little, Purdue University.*

Find the moment of inertia of the area of a rectangle, dimensions b and h, with respect to a line through the centroid which makes an angle of ϕ with the base of the rectangle.

Solution by the proposer.

Let the dimensions of the rectangle be b and h. Set up coördinate axes with the origin at the centroid and with the x-axis along the line about which moments are to be taken. Let the angle which one side makes with the x-axis be ϕ. See figure. The equations of the sides are then:

$$\text{Side } AB \qquad y=-x\cot\phi+\frac{h}{2}\csc\phi.$$

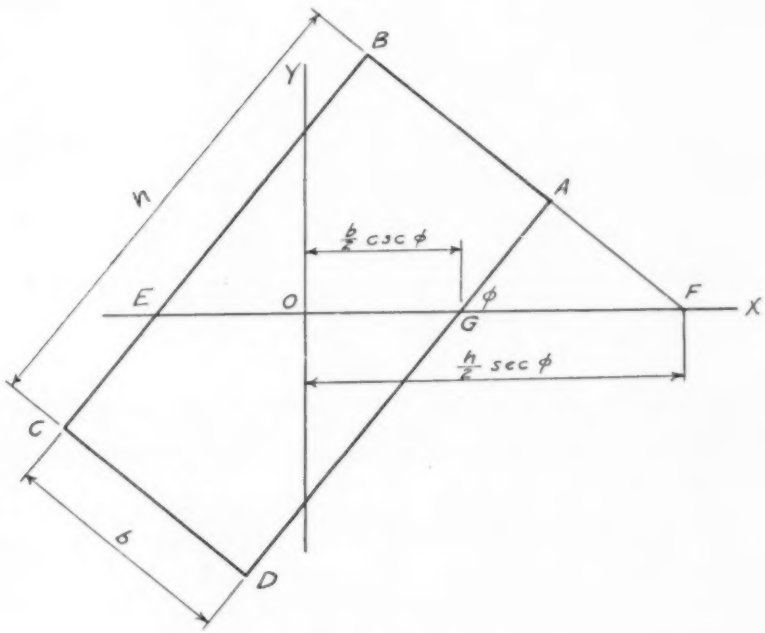
Side AD $\qquad y = x\tan\phi - \frac{b}{2}\sec\phi.$

Side BC $\qquad y = x\tan\phi + \frac{b}{2}\sec\phi.$

The coördinates of points A and B may be found and are

$$A\left(\frac{h\cos\phi + b\sin\phi}{2},\ \frac{h\sin\phi - b\cos\phi}{2}\right),$$

$$B\left(\frac{h\cos\phi - b\sin\phi}{2},\ \frac{h\sin\phi + b\cos\phi}{2}\right).$$



The moment of inertia of the rectangle is two times that of the triangle EBF minus two times that of the triangle AGF. Hence

$$I = z\int_0^{1/2(h\sin\phi + b\cos\phi)} \left[\left(\frac{h}{2}\sec\phi - y\tan\phi\right) - \left(y\cot\phi - \frac{b}{2}\csc\phi\right)\right] y^2 dy$$

$$- z\int_0^{1/2(h\sin\phi - b\cos\phi)} \left[\left(\frac{h}{2}\sec\phi - y\tan\phi\right) - \left(y\cot\phi + \frac{b}{2}\csc\phi\right)\right] y^2 dy.$$

This evaluated gives

$$I = \frac{bh}{12}(h^2\sin^2\phi + b^2\cos^2\phi).$$

It is interesting to note that from this it follows easily that the moment of inertia of a square is independent of ϕ.

A solution was also offered by Charles W. Trigg.

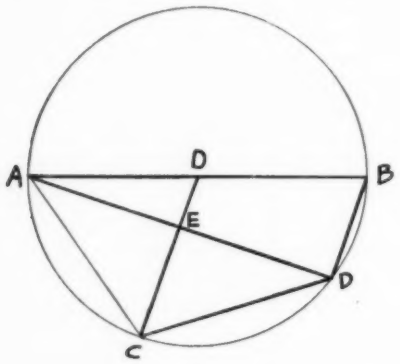
1511. *Proposed by D. A. Wallace, St. Paul.*

Prove by a method other than the one usually given in textbooks, that the side of a regular inscribed pentagon is $R/2\sqrt{10-2\sqrt{5}}$, where R is the radius.

Solution by the proposer.

Let AB be the diameter of a circle whose center is 0, and let AC and CD be sides of a regular inscribed pentagon. Then BD is the side of regular inscribed decagon.

Draw AD and OC intersecting AD at E. C is the midpoint of arc AD. Therefore OC bisects and is perpendicular to AD. OC is parallel to BD, since BD is also perpendicular to AD.



Therefore OE, the projection of AO upon OC, is equal to $\frac{1}{2}BD$. From geometry $BD=\frac{1}{2}R\ (\sqrt{5}-1)$. Therefore $OE=\frac{1}{4}R(\sqrt{5}-1)$.

Therefore, by the formula for the square on a side of a triangle opposite an acute angle:

$$AC^2=2R^2-2R\times\tfrac{1}{4}R(\sqrt{5}-1)=\frac{8R^2}{4}-\frac{2R^2\sqrt{5}}{4}+\frac{2R^2}{4}$$

$$=\frac{10R^2}{4}-\frac{2R^2\sqrt{5}}{4}$$

$$=\frac{R^2}{4}\cdot(10-2\sqrt{5}).$$

Therefore $AC=\frac{1}{2}R\sqrt{10-2\sqrt{5}}$

1512. *Proposed by G. V. Cox, Warren, Ill.*

In a triangle APQ, A is a fixed point while P moves on a fixed line CD. AP meets a fixed line TW parallel to CD in R, angle APQ is fixed and $AR=PQ$. Show that Q lies in a straight line.

Solved by Aaron Buchman, Buffalo, N. Y.

Construct $AY\perp TW$ cutting TW at Y and CD at X. Construct $\angle AXV=\angle APQ$ and $XV=AY$. Draw AV and VQ.

Since $TW\|CD$, $\dfrac{AP}{AR}=\dfrac{AX}{AY}$, but $AR=PQ$, $AY=XV$ $\therefore$ $\dfrac{AP}{PQ}=\dfrac{AX}{XV}$.

Now $\angle AXV = \angle APQ \therefore \triangle AVX \sim \triangle APQ$, and $\angle XAV = \angle P$

$\therefore \angle YAR = \angle VAQ.$ (1)

Since $\triangle AXV \sim \triangle APQ$, $\frac{XV}{AV} = \frac{PQ}{AQ}$

and $\frac{AY}{AV} = \frac{AR}{AQ}$. (3)

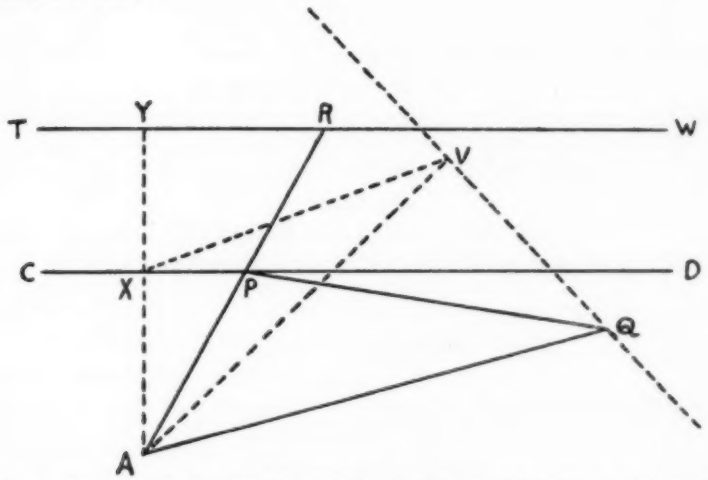
From (1) and (2)

$\triangle YAR \sim \triangle VAQ$

But $\angle AYR$ is a right angle.

$\therefore \angle AVQ$ is a right angle.

Since AV is fixed in length and position, the locus of Q is a straight line through $V \perp AV$.



A solution was also offered by Walter R. Warne, New York University.

1513. *Proposed by George W. Haas, Lakefield (Minn.) High School.*

Find two numbers such that their sum added to their product is 47, while their sum subtracted from the sum of their squares is 62.

First Solution

By Julius H. Hlavaty, Evander Childs High School, N. Y. C.

Let x and y represent the two numbers.

Then by the conditions of the problem:

$$x+y+xy=47$$
$$x^2+y^2-(x+y)=62$$

Add twice the first equation to the second,

$$x^2+2xy+y^2+(x+y)=156$$

Solve as a quadratic equation for $x+y$:

$x+y=-13$ $\qquad$ $x+y=12$

Combining each of these equations with the first equation and solving each pair for x and y we find:

$x=\frac{-13\pm\sqrt{-71}}{2}$ $\qquad$ $x=5$ $\qquad$ $x=7$

$$y=\frac{-13\mp\sqrt{-71}}{2} \qquad y=7 \qquad y=5$$

Second Solution

By James V. Bernardo, Plainville, Connecticut.

Let x equal one of the required numbers and y, the other. Then, from the conditions of the problem,

$$xy+x+y=47 \tag{1}$$

$$x^2+y^2-x-y=62 \tag{2}$$

Factoring equation (2),

$$x(x-1)+y(y-1)=62 \tag{3}$$

And from (1),

$$=\frac{47-x}{x+1}. \tag{4}$$

Substituting (4) in (3) and simplifying,

$$x^4+y^3-61x^2-265x-2100=0.$$

By synthetic division we find that 7 is a root of the above equation. Therefore, substituting $x=7$ in (1), we get $y=5$.

Thus, the two numbers required are 5 and 7.

Third Solution

By Daniel Finkel, New York, N. Y.

$x+y=47-xy$. Substitute (1) in the 2nd equation above. (1)

$$x^2+y^2-47+xy=62$$

$$x^2+y^2+xy=109$$

$$x^2+y^2+2xy=109+xy$$

$$(x+y)^2=109+xy \tag{2}$$

Now $(x+y^2=47^2-94xy+x^2y^2=xy+109$. From (1) and (2)

$$x^2y^2-95xy+2100=0$$

$$(xy-35)(xy-60)=0$$

Now put $\begin{cases} xy=35 \\ x+y=12 \end{cases}$ and $\begin{cases} xy=60 \\ x+y=13 \end{cases}$

The first pair when solved yields to the solutions $\begin{pmatrix} x=5 & y=5 \\ y=7 & x=7 \end{pmatrix}$ while the second pair of equations gives

$$\left\{\begin{matrix} x=\dfrac{-13+\sqrt{-71}}{2} & x=\dfrac{-13-\sqrt{-71}}{2} \\ y=\dfrac{-13-\sqrt{-71}}{2} & y=\dfrac{-13+\sqrt{-71}}{2} \end{matrix}\right\}$$

Solutions were also offered by H. M. Zerbe, Charles W. Trigg, Los Angeles, Walter R. Warne, New York City, E. A. Bahabunmi, Monrovia, Liberia, D. F. Wallace, Minnesota, Allin W. Jackson, Kamleops, B.C., W. R. Smith, Aaron Buchman, Buffalo, O. Harold Johnson, Chicago, Kenneth P. Carlson, Brule, Nebraska, David Rappaport, Chicago, and the proposer.

HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems

submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

No names to report. Come on high school students, with your solutions.

PROBLEMS FOR SOLUTION

1526. *Proposed by Chin Chin Shoo (1247 A. D.)*

There is a circular city of unknown diameter having four gates. Three miles north of the north gate is a tree which is just visible from a point nine miles east of the south gate. Find the diameter of the city.

1527. *Proposed by Charles P. Louthan, Cleveland.*

The sphere $x^2+y^2+z^2=100$ is cut by plane $z=8-.3x-.2y$. By use of trigonometry, find the radius of the circle of intersection.

1528. *Proposed by David Rappaport, Chicago.*

Two circles of radii one inch and two inches are tangent to each other externally. Both are tangent internally to a circle whose radius is three inches. A fourth circle is tangent to all three circles. Find the radius of the fourth circle.

1529. *Proposed by Walter Cummings, Compton, Calif.*

Construct a regular hexagon with ruler and compass such that four consecutive sides shall pass respectively through any four given points. Also show that by the aid of a protractor a similar problem can be solved for a polygon of n sides.

1530. *Proposed by D. F. Wallace, Minn.*

Given a circle and two chords AB and AD of unequal lengths, find in the arc subtended by the angle BAD, a point C so that a circle may be inscribed in the quadrilateral $ABCD$.

1531. *Proposed by Isadore Chertoff, Bayonne, N. J.*

If a, b, c, d, the sides of any quadrilateral, are in arithmetic progression, show that the area is

$$\sin\frac{A+C}{2}\sqrt{abcd}.$$

SCIENCE QUESTIONS

December, 1937

Conducted by Franklin T. Jones

(Send all communications to Franklin T. Jones, 10109 Wilbur Avenue, S. E. Cleveland, Ohio.)

Readers are invited to co-operate by proposing questions for discussion or problems for solution.

Examination papers, tests, and interesting scientific happenings are very much desired. Please enclose material in an envelope and mail to Franklin T. Jones, 10109 Wilbur Ave., Cleveland, Ohio. Thanks!

Your classes and yourself are invited to join the GQRA (Guild Question

Raisers and Answerers). More than 190 others have already been admitted to membership by answering a question or proposing one that is published.
BECOME MEMBERS OF THE *GQRA*

THE QUESTION WITH 100 ANSWERERS

Wanted

A new or old member of the GQRA to submit a question of such interest that 100 Answers will be sent in to the Editor.

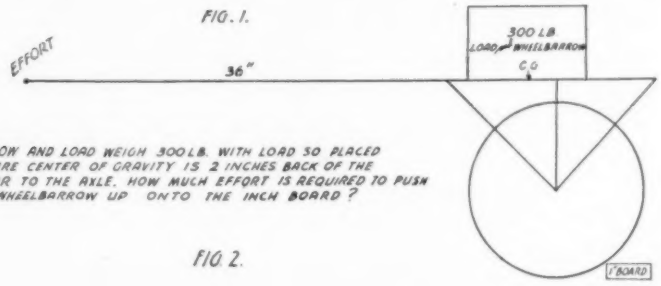
Teachers get your classes to working on such a question. Thanks!

HOW LOAD THE WHEELBARROW

816. *Submitted by J. B. King, (GQRA No. 88), in behalf of LeRoy Simkins, elected to the GQRA, No. 197, and Donald Fleming, elected to the GQRA, No. 198, all of Corsica-Union High School, Corsica, Pa.*

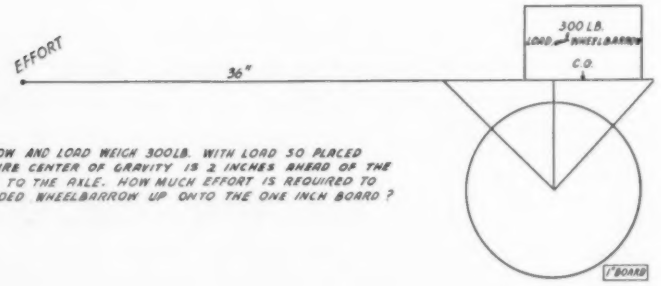
A discussion concerning levers and simple machines in my physics class brought up a question from two of its members LeRoy Simkins and Donald Fleming concerning wheelbarrows. The boys said that they thought it would be easier to push a wheelbarrow if it were loaded so that the center of gravity of the load and wheelbarrow was beyond the axle and the operator would then hold down on the handles and push. I contended that it would be easier to push if it were loaded so that the center of gravity was the same distance back of the axle and the operator would then hold up on the handles and push. After considerable discussion it was decided to submit a problem to your Science Questions department on the matter. We reached a conclusion but wondered if we were omitting some important factor. We submit it hoping you will find it worthy of use in your department of SCHOOL SCIENCE AND MATHEMATICS.

FIG. 1.



WHEELBARROW AND LOAD WEIGH 300 LB. WITH LOAD SO PLACED THAT THE ENTIRE CENTER OF GRAVITY IS 2 INCHES BACK OF THE PERPENDICULAR TO THE AXLE. HOW MUCH EFFORT IS REQUIRED TO PUSH THE LOADED WHEELBARROW UP ONTO THE INCH BOARD?

FIG. 2.



WHEELBARROW AND LOAD WEIGH 300 LB. WITH LOAD SO PLACED THAT THE ENTIRE CENTER OF GRAVITY IS 2 INCHES AHEAD OF THE PERPENDICULAR TO THE AXLE. HOW MUCH EFFORT IS REQUIRED TO PUSH THE LOADED WHEELBARROW UP ONTO THE ONE INCH BOARD?

I am enclosing a drawing to illustrate our problem which is as follows:—

All other things being equal which would require the lesser amount of effort to push up onto a 1 inch board and how much

(1) a wheelbarrow as in figure 1 with the load and wheelbarrow having a total weight of 300 lb. and so arranged that the center of gravity of the entire apparatus is 2″ back of the axle so that the operator lifts up on the handles and pushes, or

(2) a wheelbarrow as in figure 2 with the same total weight so placed that the center of gravity is 2″ ahead of the axle and the operator must hold down on the handles and push.

Each wheelbarrow has a wheel 12″ in diameter. The effort in each case is being exerted by the hands placed 36 inches back of the perpendicular to the axle and the body of the wheelbarrow is to be held so as to be in a horizontal position. Since the friction of the wheelbarrows could be assumed to be the same, it may be neglected in the problem. The wheel in each case is against the board to start with.

Let me know if you consider the problem worthy of your department and if so I trust that we may soon get a solution. If anything about the problem or the drawing is not clear please write me about it.

A TEXT IN HOUSEHOLD CHEMISTRY

817. *Advice requested by Carl H. Ranger (Elected to the GQRA, No. 199), St. Johnsbury Academy, St. Johnsbury, Vt.*

"I am looking for a text and laboratory manual for a course in Household Chemistry. Girls who wish to become nurses find too little in chemistry that is related to human living. . . . I wish to find something better than I am now using.

Consumers Research, Inc., have recently put out a Consumers' Test Manual that has aroused some executives to believe that such material could be woven into a course in secondary school chemistry. . . . One wonders if this effort represents the most practical subject matter for folks to consider.

I shall appreciate any suggestions you may make."

DEMONSTRATION TELEPHONE SWITCHBOARD

818. *The October, 1937, number of The American Physics Teacher contains an article by Lloyd W. Taylor (Elected to the GQRA, No. 200) and Paul F. Brown (Elected to the GQRA, No. 201), Oberlin College, Oberlin, Ohio, which should be thoughtfully referred to by every teacher of physics.*

This article (Pages 215 to 220) carries nine valuable cuts showing telephone switchboard operation. By reference to this article and the diagrams it would be possible for many schools to build the apparatus to demonstrate this equipment. It is a useful and recommended project.

The switchboard units are mounted on a beaver board panel, 4×6 ft. "The present is a strategic time to secure the necessary units, since so many manually operated switchboards are being discarded in the course of replacement by machine switching equipment. For the construction of the particular board here described, the additional facility of N.Y.A. labor was available, the process of fabrication being educational for the workers and the finished product possessing notable value as an instructional tool."

(Although this article was not submitted to Science Questions, it seems

to the Editor such a notable example of what physics teachers and physics classes ought to be doing that it is here recognized by asking the authors to accept membership in the GQRA.)

HELP FOR FORMO

805. *Jerome C. Formo, GQRA No. 102, Augsburg College, Minneapolis, Minn., proposed this "teaser" for the GQRA Picnic at Pen'Bryn, Geneva, Ohio, last summer.*

(It is not a scientific question.)

"If a hen-and-a-half lay an egg-and-a-half in a day-and-a-half, how many eggs will six hens lay in six days?"

Help comes from J. B. King, GQRA No. 88, Corsica, Pa., O. E. Underhill, GQRA, No. 99, New Britain, Conn., and W. R. Smith, GQRA No. 176, Chicago, Ill.

All obtain the same answer. Mr. King makes some comments which cause his answer to be published.

An "if" clause is always hypothetical but to solve the problem (or any problem) we must take what is given and proceed so.

$1\frac{1}{2}$ hens (imagine it) lay $1\frac{1}{2}$ eggs (again) in $1\frac{1}{2}$ days.

6 hens would lay 6 eggs in $1\frac{1}{2}$ days

because 4 times as many must lay 4 times as many eggs in the same time. In four times as many days 6 hens would lay 24 eggs in 6 days.

This should be mathematically true but not necessarily biologically true. It's like the old problem "If 300 cats catch 300 rats in 300 minutes how long would it take 600 cats to catch 600 rats?"

I always claimed that mathematics made no allowance for the brains of the cats for unless something were done to show each cat which rat was his, some rats would be well fought over while others scurried to safety.

UNFINISHED BUSINESS

Some of the things started but not finished in 1937 are mentioned below. Can you help out?

First: Did you respond to the request for "The Exchange of Biological Knowledge" from the Mercy BIO-ITE CLUB of Mercy High School, Milwaukee, Wisconsin?

Second: Answers are lacking to Questions as follows—

788. *Finding the Lusitania.*
802. *The Hindenburg Disaster.*
804. *Anhydrous Ammonia as a Motor Fuel.*
806. *Waves and Vibrations.*
807. *For the Fliers.*

Please give your classes a chance at these questions. Many will work them out, send in answers and be recognized for their effort as members of the GQRA. The boys and girls deserve the chance.

NEW MEMBERS of the GQRA—December, 1937.

197. LeRoy Simkins, Corsica-Union High School, Corsica, Pa.
198. Donald Fleming, same.
199. Carl H. Ranger, St. Johnsbury Academy, St. Johnsbury, Vt.
200. Lloyd H. Taylor, Oberlin College, Oberlin, Ohio.
201. Paul F. Brown, same.

BEGIN 1938 RIGHT—JOIN THE GQRA!

BOOKS AND PAMPHLETS RECEIVED

Experimental Radio, by R. R. Ramsey, Professor of Physics, Indiana University, Fellow American Physical Society, and Member Institute of Radio Engineers. Fourth Edition. Cloth. Pages xiv+196. 15×22.5 cm. 1937. Ramsey Publishing Company, Bloomington, Indiana. Price $2.75.

Introduction to Mathematical Probability, by J. V. Uspensky, Professor of Mathematics, Stanford University. First Edition. Cloth. Pages ix+411. 15×23 cm. 1937. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $5.00.

Plane Geometry and Its Reasoning, by Harry C. Barber, English High School., Boston, Massachusetts, and Gertrude Hendrix, Eastern Illinois State Teachers College, Charleston, Illinois. Cloth. Pages x+310. 13×20.5 cm. 1937. Harcourt, Brace and Company, 383 Madison Avenue, New York, N. Y.

Drill Book in Plane Geometry, by Robert Remington Goff, Formerly Director of Mathematics, Senior High School, New Britain, Connecticut, and revised by Mildred Gardner Weld, Chairman of Mathematics, Senior High School, New Britain, Connecticut. Cloth. Pages vi+180. 13.5×19.5 cm. 1937. The Palmer Company, Boston, Mass.

Socialized General Mathematics, by Walter W. Hart, Formerly Associate Professor of Mathematics, School of Education, University of Wisconsin, and Cottell Gregory, Louisville Girls High School, Chairman Mathematics Curriculum Committee, Louisville, Kentucky. Cloth. Pages vii+406. 13.5×20.5 cm. 1937. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $1.28.

Mathematics and Life, by G. M. Ruch, F. B. Knight, and J. W. Studebaker. Book Two. Cloth. 512 pages. 13×18.5 cm. 1937. Scott, Foresman and Company, Chicago, Ill. Price 88 cents.

Teaching Arithmetic in the Elementary School, by Robert Lee Morton, Ohio University, Athens, Ohio. Volume I, Primary Grades. Cloth. Pages x+410. 13×20.5 cm. 1937. Silver Burdett Company, 45 East 17th Street, New York, N. Y. Price $2.40.

Experimental Physics, by Samuel Robinson Williams, Professor of Physics, Amherst College. Paper. 158 pages. 19×27 cm. 1937. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $1.00.

The High-School Science Library for 1936–1937, by Hanor A. Webb, George Peabody College for Teachers, Nashville, Tennessee. Reprinted from Peabody Journal of Education, Volume 15, No. 2, September, 1937. 15 pages. 17×24 cm. Price 15 cents.

Aids to the Student of Conservation, by Stephen S. Visher, Professor of Georgraphy, Indiana University. Paper. 32 pages. 21×27.5 cm. 1937. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price 25 cents.

Chemcraft—Chemistry of Foods and Household Materials, No. 7. Directions for 337 Experiments. Explanation of Chemical Science and Industries, written under the direction of Harold M. Porter. Paper. 107 pages. 12.5×20.5 cm. 1937. The Porter Chemical Company, Hagerstown, Md.

The Instruction Manual for Chemcraft. Chemistry Outfit No. 25, covering Science, Chemical Industries, and Chemical Magic. Directions for Performing 814 Experiments, by Harold M. Porter and Jermain D. Porter. Paper. 237 pages. 12.5×20.5 cm. 1937. The Porter Chemical Company, Hagerstown, Md. Price $1.50.

Science Craft—Polaroid Junior Instruction Manual, written under the direction of Harold M. Porter. 31 pages. 12.5×20.5 cm. 1937. The Porter Chemical Company, Hagerstown, Md.

Mammals of Circus and Zoo, by Edith A. Pickard, Associate Professor of Biological Science, San Francisco State College. Includes a Curriculum of Mammals of Circus and Zoo developed in the Saratoga Union School. Volume III, No. 6, January, 1937 of *Science Guide for Elementary Schools.* Published by California State Department of Education, Sacramento, Calif.

Mathematics for Elementary Schools, State Syllabus. Published by the State of New York Press. Paper. 192 pages. 1937. State of New York, Education Department, Albany, N. Y.

Goode's Series of Base Maps, edited by Henry M. Leppard. 60 titles. The University of Chicago Press, 5750 Ellis Avenue, Chicago, Ill. Prices vary with size of map and quantity ordered. Free sample sent on request.

BOOK REVIEWS

Business Mathematics, by Lucien Blair Kinney, Ph.D., Chairman, Department of Mathematics, Univ. of Minnesota High School, College of Education, University of Minnesota. Cloth. Pages vii+360. Henry Holt and Company, New York. 14×20 cm. 12 mo. Price $1.32.

This well written, well organized book on mathematics maintains that the effective use of mathematics as a means of studying and solving business problems must go beyond a stress on the mechanical skills of arithmetic, and must include the study of graphs, formulas, tables and other mathematical devices.

The aim of the book is very evidently to show that business mathematics should be a study of the nature, organization and conduct of business through the use of mathematics. One commendable feature of the text is the emphasis laid upon business information, vocabulary and the power to combine these with the mechanical arithmetic skills in the solution of business problems.

The book can be easily adapted to individual differences in ability, need and interests of pupils. It seems to the reviewer that with a little careful planning on the part of the teacher, any one of the popular methods of presentation can be used—problem, project, daily recitation or long-unit assignment.

The numerous practice exercises given from time to time afford sufficient opportunity for developing the necessary skill in the fundamental operations in arithmetic. Remedial work for further practice can be given at times when chapter tests reveal need for it.

Since the book is the result of nine years of research and investigation of the actual needs and requirements of business through an extensive interview with workers and managers of business units, it should forcibly

recommend itself to schools as a genuine contribution to the teaching of business transactions.

The reviewer feels that a book of this type would be a suitable book for each high school student to master before graduation.

A. A. SPERLING

Modern-Life Chemistry, by Frank O. Kruh, Soldan High School, St. Louis, Missouri, Robert H. Carleton, Summit High School, Dayton, Ohio, and edited by W. R. Teeters, Supervisor of Physical and Biological Sciences, St. Louis Public Schools. First Edition. Pages xxv + 734. 14×19× 3 cm. Illustrated. Cloth. 1937. $1.80. J. B. Lippincott, Philadelphia.

A thoroughly modern treatment based on sound pedagogical principles is evidenced in this new textbook of general chemistry for use in high school courses. The unit plan of study is consistently used. There is in evidence an attempt to teach basic ideas, principles, and laws as well as the facts from which these spring, and to show the pupil how these things concern him in his life. The subject matter is up to date (almost too up to date in places, as when the physics of the atomic nucleus is daringly brought to the attention of the student). Streamline trains, "tempered" glass, Bergius process gasoline, heavy water, etc., attest the modern character of the book. The usual chapters are replaced by fewer and larger "unit" topics, of which there are but eleven in all. The first unit is styled "Foundations of Chemistry" and uses the chemistry of oxygen, hydrogen and water as subject matter, somewhat as most courses do but perhaps more briefly. The second unit, on "The Structure of Matter" plunges into the modern conceptions after a brief, but excellent treatment of Dalton's atomic theory, the Gay Lussac Law, and Avogadro's Law. The third unit on "Solutions and Near-Solutions" is concise but excellent. A study of "Chemical Action in Solution" follows and then Chemical Equations and Calculations are studied. The remaining units present most of the descriptive chemistry of the text. Every wide awake teacher of high school chemistry should examine this new text for much of originality is exhibited by its authors.

FRANK B. WADE

Experiments in Modern Life Chemistry, by the same authors as the above text and intended to be used with it, is a modern work-book-laboratory-manual containing 86 experiments given in the order of the text. A rapid glance through the manual shows that the directions for the experiments are well worked out and that cautions are given in most places where necessary. The reviewer would suggest that more use of the teacher demonstration method instead of the pupil experiment might be made in at least several of the more dangerous experiments, such as those that use yellow phosphorus, concentrated nitric acid, etc., but the directions and cautions, if followed, should prevent accident. The leading questions followed by blanks to be filled in, provide for as much "note book writing" as is profitable. An excellent companion to the textbook.

FRANK B. WADE

An Advanced Course in General College Physics, by Paul Leverne Bayley, Associate Professor of Physics, Lehigh University and Charles Clarence Bidwell, Professor of Physics, Lehigh University. Cloth. Pages v+340. 13.5×21.5 cm. 1936. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.50.

This book is a wide departure from the typical general physics text for

college students. It presupposes the equivalent of about a year and one-half of college mathematics and considerable knowledge of descriptive physics including ability to solve problems illustrating the use of fundamental principles. As a text for a first course in college physics it is suitable only for selected students who have thoroughly mastered the high school course. The calculus is used throughout but acquaintance with the meaning of the derivative and with simple integrations is all that is required in the early chapters, thus making it possible for the student to carry this course along with a course in calculus if he has had a strong course in analytics or general college mathematics.

Many schools may want to use this text as the basis for the work of a second-year course. Students wanting a minor in physics for supporting major work in other sciences and those preparing to teach physics in the secondary schools often find that the specialized physics courses which follow the general course do not give sufficient breadth of experience in the time available. This text offers a solution to this problem except perhaps in one respect: it fails to supply sufficient material in modern physics. Only one short chapter of twenty-two pages is devoted to electronics and quantum theory; all the rest of the book is classical physics.

Omission of much of the descriptive material usually given in general physics texts makes it possible to cover the basic principles in a book of about half the normal size. Many numerical problems are provided and some general problems. A few involve only direct use of principles but many of them will test the ability of the best students. The book is well written and illustrated, and is remarkably free from the usual errors of a first edition. It is a pioneer book and merits consideration for use in classes sufficiently prepared for an advanced course.

G. W. W.

Scientific Inference, by Harold Jeffreys. Cloth. Pages vi+272. 13.5×22 cm. 1937. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.25.

This book first published in 1931 has been reprinted with several valuable additions. It is one of the few books written on the theoretical interpretation of scientific data. The first chapter defines and discusses the differences between the terms logic and scientific inference. The next seven chapters deal with the topics of probability, sampling, quantitative laws, errors, physical magnitudes, and mensuration. The four chapters following discuss the mathematical possibilities contained in Newtonian dynamics, light and relativity, and other theoretical aspects of scientific knowledge. The remainder of the book includes three appendices on probability in logic and pure mathematics, infinite numbers, an analytic treatment of the sine and cosine, several lemmas, and an index.

In addition to the fact that the content is unusual and the discussions unique, the book possesses several noteworthy features. The author has illustrated and proved many of his statements by simple, clean-cut examples. As each new topic is taken up it is classified by giving it a number corresponding to the chapter and its position in it. The book is written in a style which is easily understandable and does not require rereading as is often the case in many books of this nature. Anyone interested in compiling and interpreting scientific data will find it a valuable reference.

L. C. WARNER

When you change address be sure to notify Business Manager W. F. Roecker, 3319 N. 14th Street, Milwaukee, Wis.

COSMIC RAY BALLOONS RECOVERED

Eleven of the twelve cosmic ray recorders released on balloons this summer by Dr. Robert A. Millikan and Dr. H. Victor Neher of the California Institute of Technology, have been returned to the Institute.

The eleventh was found by a Canadian farmer on Sept. 26 while he was looking for horses. The instrument was found dangling from a tree. The still missing balloon is somewhere in Canada.

Four recording electroscopes (the device which registers the passage of a cosmic ray) were sent aloft by means of balloons by the two California scientists from Saskatchewan Province in Canada and eight from Omaha, Neb. All eight of the balloons sent up from Omaha have already been returned.

The highest altitude achieved was between 83,000 and 84,000 feet, a height gained by one of the Omaha balloons. Canadian records that have been developed show the maximum altitude reached to be from 73,000 to 74,000 feet.

The eight instruments released in Nebraska were recovered within 90 miles of Omaha, while the instruments sent up in Canada drifted as far as 180 miles from the starting point.

FIFTH AMERICAN PLANETARIUM OPENED TO PUBLIC

America's fifth planetarium was opened to the public in the Museum of Natural History at Springfield, Mass., on Tuesday, Nov. 2. Using American-made equipment and Yankee ingenuity, the complete outfit cost the museum about one-tenth as much as was paid for the other planetariums in this country.

Novel projector design, worked out by Frank and Stanley Korkosz, both of the museum staff, cut projector cost from the $150,000 charged for most European instruments to $12,000. Special "twinkling" effects, worked out by the Korkosz brothers, add reality to the projected star images.

"Comets" projected by a special lens system, will displace the customary illuminated arrow used by the lecturer in pointing out the subject of his speech. Museum officials believe that their low-cost installation will be a precursor of many such in smaller institutions serving population areas of less than 250,000 inhabitants.

COLLEGE STUDENT UNEARTHS MANY ICE AGE FOSSILS

Fossilized bones of Ice Age animals have been unearthed in large numbers by Hugh M. Rutledge, 21-year-old student at Presbyterian College, Clinton, S. C., conducting excavations at Edisto Beach State Park, S. C., the U. S. National Park Service has announced. Among the 1582 pieces of fossilized bone were representative fragments of royal bison, giant armadillo, tapir, giant beaver, extinct horse, mastodon, mammoth, giant sloth, whale, and sea cow.

RADIUM

Radium still gives clews to earth age, which is in excess of 1,750 million years, according to Dr. Arthur Holmes, eminent British student of geologic phenomena. Reviewing the evidence, and correcting it for the most recent information, Holmes finds that the earth is more than 2,000 million years old. Other evidence, much of it astronomical, indicates that the earth cannot be older than 4,000 million years. From the evidence collected by him from many sources, Holmes suggests that the "earth, solar system, meteorites, and galaxies, all came into existence about the same time—some 2,000 million years ago."

Preparation of Manuscripts for Publication in School Science and Mathematics

MANY articles come to our editorial office before they have been put in condition for our use and hence must be rejected. The spelling, punctuation, sentence structure, and all mechanics of the manuscript should be correct before it is submitted. Do not count on making such corrections when you receive the galley proof. All changes in proof mean extra expense. This journal is not endowed and all expenses must be paid out of receipts from subscriptions and advertising. It is a cooperative enterprise. Make your original manuscript exactly right and perfectly clear.

Papers for publication should be sent to **Glen W. Warner, Editor, 7633 Calumet Avenue, Chicago, Ill.** Return postage should be included if the manuscript is to be returned if rejected.

Manuscripts submitted should not have been published elsewhere. They should be original typewritten copies, double or triple-spaced with wide margins on 8½″ x 11″ paper.

References and footnotes should be numbered consecutively throughout the article and indicated by superior numbers. The reference or footnote should be set off by rules and placed immediately below the citation.

Bibliography should be given thus:
FRANKLIN, G. T. "Analysis in First Year Chemistry," *Journal of Chemical Education*, 7, pp. 361-364, February, 1930.

Drawings should be made on good quality white paper in black India ink. Letters, numbers, etc., which cannot be set in type at the margin of the cut must constitute a part of the drawing. They should be proportioned to insure legibility in the cut. Illustrations to appear as full page productions should be proportioned suitable for a 4″ x 7″ page.

Tabular Material should be proportioned to suit page width. All tables should be double ruled at the top just below table number and heading; use single rulings for columns, sub-divisions and bottom. References to illustrations and tables should be by number, as "see Fig. 3," and not to position, as "the following table." It may not be possible to set the drawing or table at a specific position with respect to the discussion.

Reprints are supplied only when ordered and at approximate prices quoted on Reprint Order Card which will be sent you with galley proof. Orders for less than one hundred reprints cannot be accepted.

Read galley proof as soon as received, indicate corrections clearly in pencil and return to the Editor immediately.

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CURRENT × IMPEDANCE = POTENTIAL

An alternating current without harmonic has the complex formula:

Current × Impedance = Potential

for example:

$$(2.4 + i\,1.8) \times (5 - i\,2) = (15.6 + i\,4.2)$$

An alternating current with harmonic has the bifoliate formula:

Current × Impedance = Potential

for example:

$$(1.8 + h\,0.6 + i\,1.7 + j\,0.1) \times (5 + i\,4 - j\,6) = (2.8 + h\,12.8 + i\,12.1 - j\,7.9)$$

The two products, complex and bifoliate, are computed by using the common multiplication table following:

×	1	h	i	j
1	+1	+h	+i	+j
h	+h	+1	+j	+i
i	+i	+j	−1	−h
j	+j	+i	−h	−1

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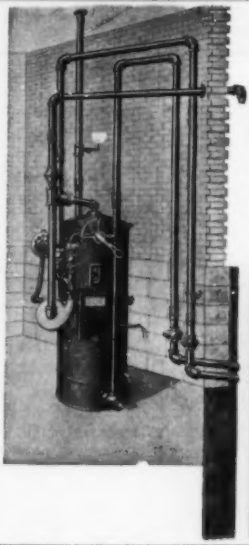

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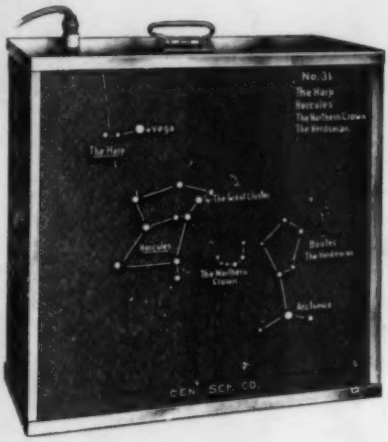

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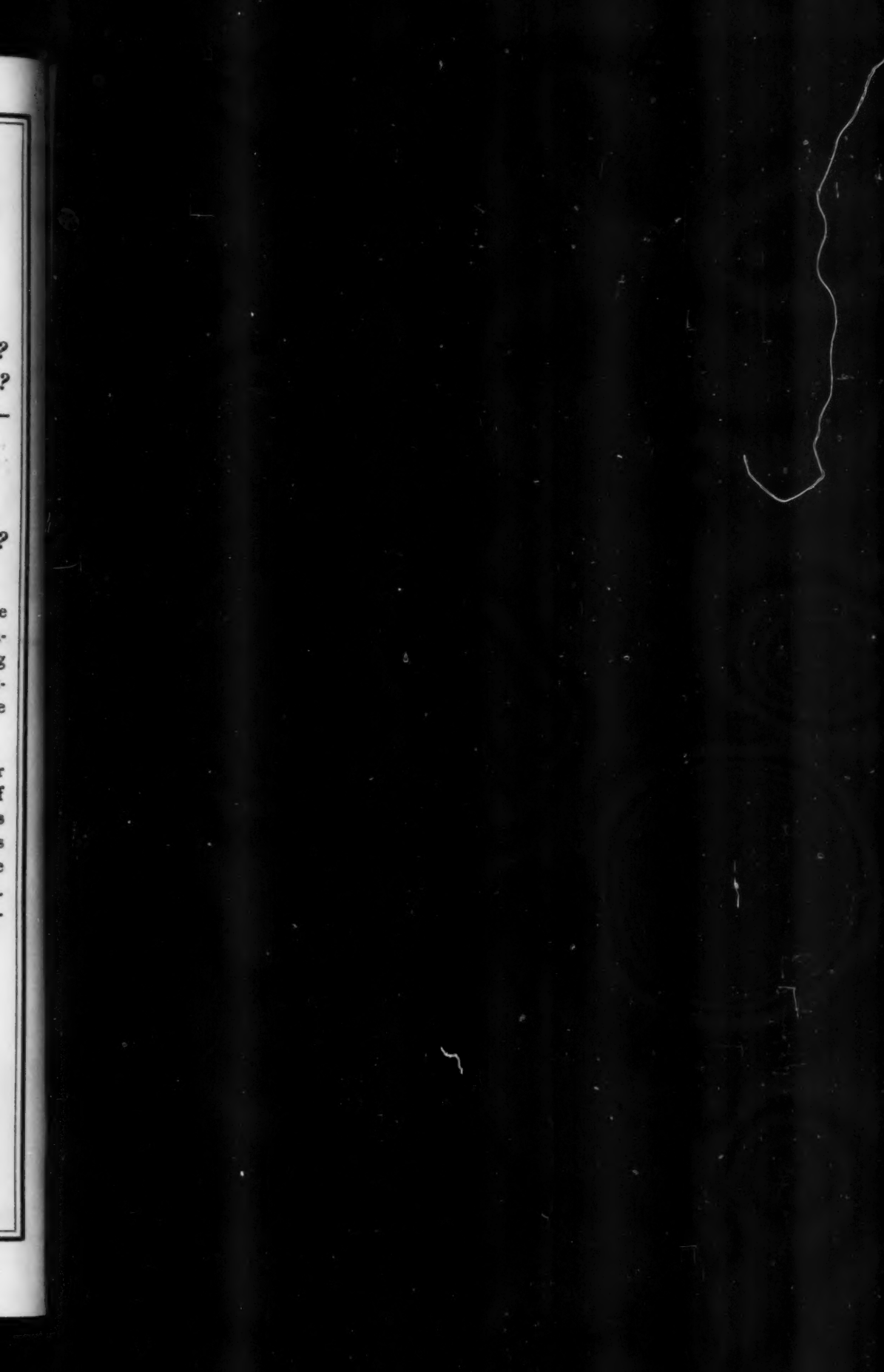
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